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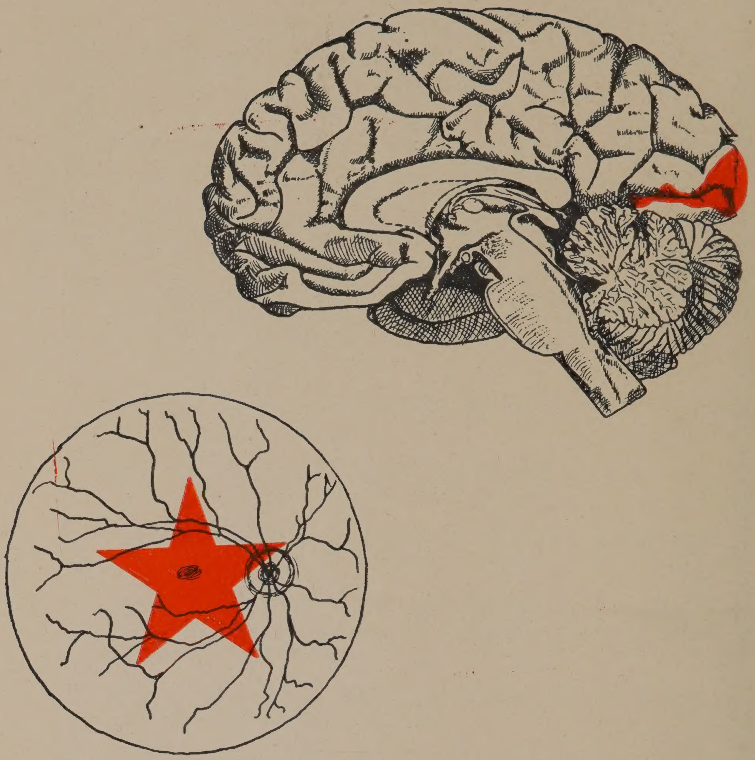

The Relation of the Retina to the Cerebral Cortex
(*Adapted from Ladd & Woodworth*).

The upper section of this figure shows the view of the brain obtained by cutting it in half vertically along the plane separating the two cerebral hemispheres. The lower section shows the retina of one eye, with its blood vessels and other anatomical features. The red star on the retina is represented on the visual area of the cortex by the irregular red figure which is shown.

(See page 102).

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THE
MYSTERY OF MIND

BY

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To

My Father

PREFACE

This book is primarily intended for the reader who has not made a special study of modern psychology. Its purpose is to acquaint such a reader with the nature of the problems which this science is considering, and to reveal the importance of these problems for human life. "Psychology" is a word which is upon everyone's tongue at the present day. But there are few who use the word who realize all that it really represents. Popular references to "psychology" sometimes point in the right direction, but they seldom touch any feature of mind which is fundamental or general. They flit eccentrically over the surface of a great subject. They graze it where its features are bizarre or of passing practical interest. They do not dig through the crust of commonplaceness hiding the astonishing details which underlie our everyday mental processes. Consequently I have endeavored in the present volume to outline the tasks of scientific psychology so that the lay reader will appreciate their true nature and significance.

However, this does not necessarily mean that there is nothing here for the reader who considers himself well versed in modern psychology. There are many different editions of this science, and I trust that in my version there is some small degree of novelty and of contribution to progress. Simplification of statement is not entirely unwelcome even to a sophisticated reader, in his leisure hours. Moreover, it is hoped that the emphasis upon the mystery and romance of mind may carry some message of inspiration even to the professional psychologist, who often becomes swamped in technical details and loses his vision of the whole. Some of my colleagues do not seem to appreciate the mysteriousness of mind, because they have become so used to studying it. Possibly some of them believe that they have succeeded in dissipating all of the mysteries! If so they need to awake and rub their mental eyes and take a general view once more.

On the practical side, I wish to acknowledge my indebtedness to several persons. Firstly, to my good friend, M. Luckiesh for the opportunity to include a book in the present series. Secondly, to my wife for her assistance and encouragement in the preparation of the manuscript. And finally to Mr. A. D. Fuller, Jr., one of my students in psychology, for his helpful criticism of the method and style of presentation.

L. T. Troland

Harvard University,
Nov. 1, 1925

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THE MYSTERY OF MIND

CHAPTER I

PSYCHOLOGY AND HUMAN PROGRESS

THE popular conception of the province of psychology is largely erroneous. People say that psychology is an interesting subject, but the problems upon which professional psychologists spend most of their time, interest practically no one else. To the "man in the street," psychology stands for hypnotism, spirit phenomena, and how to make a sale. He does not realize that psychology deals with all of the most essential principles of his own nature and also with the "street" and the whole world in so far as he is directly cognizant of these things. The present book attempts to outline the problem of psychology in such a way as to reveal the tremendous scope of its field. Psychology is a unique science in that it has an application to practically every human problem. Whether we are thinking, feeling, seeing or acting, psychology finds facts to study and baffling problems to solve. The mystery of mind looms up at every point in human life.

There are relatively few "men in the street" who appreciate this ubiquity of the mystery of mind. This is because mind does not naturally like to think about itself; or at any rate to do so consciously. It takes the nearly abnormal mind of a born philosopher to think about mind spontaneously. However, when once these subjective lines of thought have been started they can be transferred to other individuals through instruction. A book or a college course in psychology is intended to provide such instruction and thus to turn the attention of thought to realities which surround it on all sides and from which it never can escape — although it may continually fail to notice them. A change from the naïve attitude towards life to that which is inculcated by modern psychology should have an effect upon the normal mind somewhat similar to that which goes with conversion to religion. Reality appears in an entirely new intellectual light.

Psychic Phenomena

To those who have not as yet received this enlightenment, there is no mystery of mind apart from rarity or strangeness. Coincidences of thought, such as are often explained by the idea of telepathy, are mysterious for this reason. When an idea occurs to us from no apparent outside source and it turns out to be true we feel that here is something which requires special explanation. If we read of the event in a telegram or see it happen before our eyes, we do not regard our knowledge as mysterious. Yet the processes of sensation, perception and recognition of meaning which are involved in these commonplace experiences are still baffling the psychologist and will continue to do so for many years to come.

Notwithstanding these considerations, the reader may be disappointed to find that the present book has little or nothing to say concerning the mysteries which are being investigated by modern psychical research. There are several reasons for our neglect of these problems. In the first place, it is not clear that all of these phenomena are distinctively mental. The tipping of tables, rapping sounds, floating lights, the extrusion of "ectoplasm," etc. have the same relations to mind that are exhibited by normal events in the external world. The mystery is physical rather than mental. The events which have been seen or heard in the presence of certain mediums are regarded as mysterious because they apparently lack the customary physical causes of such events. It cannot be inferred from this fact alone that the causes are "mental" or "psychical."

However, if investigation shows conclusively that appropriate physical causes actually are absent, we may then reasonably inquire whether the true causes are not psychological in nature. The psychologist knows that floating lights can be seen without anything being physically present before the eyes of the observer. In this case they are said to be products of *imagination* or *hallucination*. However, if this is the correct explanation the mystery seems to be swept away, for hallucination is a well-known process. But it is not a well *understood* process, and for the general psychologist the real mystery is as to how hallucinations of any kind are possible. The mystery of the "psychic appearances" is swallowed up in that of appearances in general. Thus, although such phenomena enter the domain of psychology they do not stand out as of salient interest, unless one has a personal reason for studying them.

A second reason for failing to lay emphasis upon these phenomena lies in the doubt which attaches to their authenticity in the majority of instances. The witnesses may be honest and reliable, but the circumstances under which the observations are made are ordinarily such as to favor illusion and delusion. The appearances are sporadic and unreliable. They inspire confidence only in the minds of those who are predisposed to believe in them. We cannot rule them out from the list of topics which must be considered by science, but we are forced to place them nearly at the bottom of the list. The modern psychologist tends to regard alleged psychical phenomena much as the modern physicist looks upon perpetual motion machines. He and his scientific predecessors have been hearing about them since the dawn of rational thought; but thus far they have never seen one clearly and honestly demonstrated. However, either the psychologist or the physicist may conceivably be forced by facts to alter their views in the future.

A third reason why we have neglected so-called psychical mysteries in this book is that it has been our main purpose to present a mystery which is *not* popularly appreciated. Mind is the commonest of all things and hence seems to be the least mysterious. An appreciation of the real nature of mind is not so common. Even less common is a recognition of its strange relationship to the physical world. The "mystery of mind" lies essentially in this relationship, the general nature of which we shall endeavor to make clear. The mystery of mind which thus appears also creates a *mystery of matter*. When we see how things stand between the facts of psychology and those of physics, we wonder which set of facts represents the more fundamental reality. How can they be combined to form a comprehensive view of the universe. Here is a mystery which is so broad in its relationship to the world in which we live that it obscures all of the detailed uncertainties which are being studied by "psychical researchers."

The Special Applications of Psychology

However, a very important question is raised when we ask what will be the practical bearing of a solution of these mysteries upon human welfare. Intellectual sentimentalists have frequently made a slogan out of "truth for truth's sake." It is to be doubted, however, whether anyone seeks truth solely for its own sake. Facts must be capable of influencing human happiness before they can be important. They can do this in the simplest possible manner when they merely *satisfy curiosity*. This reveals one of the motives of the scientific purist, and happiness derived from the satisfaction of curiosity is as good as any other kind, depending only upon its intensity and duration. We may apply the principles of science in producing a newspaper, and accomplish little else than the satisfaction of curiosity. Scientific men also labor to make their names great and to disprove the doctrines of people whom they despise; but the curiosity motive is usually regarded as a more noble one than these.

If we disregard such personal appeals, we may still seek truth in general because we are certain that all knowledge will eventually prove useful. Knowledge tells us what kind of a universe we are in, and there is presumably no portion of this universe which has no influence upon our lives. At any rate, there are no general laws or general features of reality which are lacking in such a bearing. Even if we admit that some forms of knowledge may eventually turn out to be useless, we cannot predict this in advance. We are not sufficiently wise to state that any specified line of research cannot possibly have a practical outcome. Over and over again in the history of science, points which have seemed wholly theoretical and abstract in one stage of progress have risen to tremendous practical importance in a succeeding stage. This is true, for example, of the science of electricity, which underlies the stability of our entire modern civilization.

But when we turn specifically to the problems of psychology, we do not need to utilize our general faith in the applicability of all kinds of knowledge. We can see definitely why their solution must prove of practical importance for humanity. We can see this in small, particular matters, and also in generalities. Among small matters, consider the importance of a knowledge of any sense organ and its relationship to consciousness. Our understanding of the eye and of the processes of vision can never be too great. It is always practically desirable to be able to see better, to conserve eye-sight, and to increase the variety of our visual experiences. The same considerations obviously apply to hearing or to any other sense. Until we know all phases of these sensory activities we shall be lacking some of the essentials to a most perfect control of them.

Another "small," practical domain of psychology lies in its bearing upon education, or the making of intelligent men. Methods of education have been built up largely without scientific guidance, on the basis of trial and error, the individual doctrines of some outstanding educator, or the whims of school boards and college faculties. Psychology is now trying to help; but not with too great success because of its own lack of knowledge. The more we know concerning memory, habit formation, encouragement and discouragement, the more efficiently we shall be able to educate the child and also the adult. Education is an affair of mind in relation to the world about it.

Business and the professions can also be helped by psychology. They need improved ways of testing and measuring men, so that individuals can be fitted into the economic scheme with the least possible lost effort and unhappiness. Many systems of "mental tests" have been devised for this purpose. The principles of scientific psychology have been applied in the production of these tests so far as possible. However, for the most part they are the product of general imagination and empirical trial. Advance in our knowledge of the nature of intelligence and of divers special abilities should enable the psychologist to develop tests which will provide a much more effective selection of men for particular positions in the business and social world.

The understanding and treatment of mental disease is another special field in which the progress of psychological knowledge has a very practical bearing upon human welfare. We have already advanced a long way beyond the once prevalent view that these disorders of thought and behavior are due to "possession by evil spirits" which only need to be exorcised by maltreatment of the unfortunate individual. However, there is still a vast amount to be learned. Specialists in mental disease are divided between various conflicting camps. Some overemphasize the conscious and subconscious factors which are involved while others seem to lay undue stress upon purely physiological considerations. True scientific progress will reconcile these different views and lead to a wiser and more successful handling of the insane or mentally deranged.

A closely related and more general field of usefulness for psychology lies in mental hygiene for the average individual. We all have some traces of abnormality in our psychological make-up. Delusions and conflicts, over or under emotionality, incapacity for effective work, and the like, are common phenomena. Psychology should show us how to remedy these troubles. It should provide methods which have the same function as those of Couéism or Christian Science, but which operate more surely and efficiently. In order to do this, psychology must know more about the processes which underlie human motives.

When we think along this line we are led to wonder whether an advanced science of psychology might not be able to direct the mind towards achievements which would be quite impossible without its aid. Might it not lead us to intellectual processes which would now seem superhuman? Might it not raise the general level of human ability to a point where the common men would be geniuses and the geniuses supergeniuses? Could it not show the path to imaginative creations in literature, graphic arts or music excelling the best that we now possess? We do not know the answers to these questions, but affirmatives seem likely.

The General Application of Psychology

However, in the thought of the present writer, the practical significance of psychological progress lies not in these "small, particular" applications, but rather in a much broader application. Psychology is in a position — similar to that of no other science — in which it can attack the problem of "application" in general. It may reach an understanding of what the word "practical" means from start to finish. In our present-day philosophy we regard anything as "practical" if it is a successful means to something else, no matter what the latter may happen to be. In general, anything which "makes money" is practical. Hence, in the last analysis many things are considered practical means towards impractical ends.

But what is a "practical end" or purpose? This is a question which psychology may be able to answer. It may also be able to reveal all of the practical steps which must be taken in order that such an end should be attained. We doubtless know many of these steps already, but we lack an acquaintance with the program of practical life as a whole. This program can be prepared by no other science than psychology. The reason for this is that things are "practical" only in so far as they have a bearing upon the satisfaction of human motives. Psychology is the only science which is in a position to investigate these motives, to determine their fundamental natures and the conditions under which they can be most completely realized.

The practical problem which psychology thus faces is one which has its common sense solution at all times and in every place. Men have their motives and they pursue them. The same can be said of any other practical problem. Since the dawn of civilization men have built dwellings and used light. But modern science has shown them how to build and how to illuminate more effectively and easily. In the same way, psychology must show us how we can work out our motives in the most efficient manner possible. It is true that psychology cannot provide us with all of the data which are necessary for this purpose, because the facts of physical science are also involved. We cannot satisfy hunger without food. Nevertheless, psychology occupies a central position in this situation, since the physical facts are only instruments to be utilized by the mind in carrying out its inner purposes. Men build houses to satisfy their motives for shelter, ownership, and the like. The application of physical science to house-building is merely contributory to the gratification of these motives. It is "practical" and "applied" only to the extent in which it actually ministers to such gratification. The same can be said of any other utilization of scientific knowledge.

The reader may feel that he already knows his own motives adequately and that the only problem which remains is as to how to put them into effect. However, the psychologist is sufficiently well informed to have good reason for doubting the truth of this assumption. Some men know their own motives better than do others, but all have something to learn. But even if we suppose that every individual is perfectly wise in this regard, there will still be some questions concerning motives which need to be answered. For example, are all of the motives in question "good" ones? And just what does it mean to say that some motives are "good" and others "bad"? Given a complex group of interacting motives, what line of behavior will lead to the greatest total satisfaction? Can old motives be exchanged for new ones? And how? What kind of motives should we "instill" in the youth? And how? Is there any general motive which underlies particular ones, and furnishes a basis for the resolution of conflicts or the selection between the latter? These are a few of the questions which psychology must answer.

The Roots of Practicality

Here we are digging for the roots of "practicality." What do men want and why? Questions of this sort have hitherto been considered more by students of ethics and of economics than by psychologists. However it is obvious that whoever attempts to answer them is at that time a psychologist. The ethical thinkers have had a great deal to say about "good" and "bad," "right" and "wrong," "ought" and "duty"; but these conceptions must ultimately be rooted in the psychology of human motives or they will be lacking in meaning. Instead of asking what is "right" and "good" the psychologist asks what humanity fundamentally desires. The "right" and the "good" will prove to be ways of satisfying the basic motives of mankind.

Although the question of motives has always been one which has fascinated the attention of popular psychologists, the professional psychologist has fought rather shy of it until recent years. This may have been because too many human motives are in such ill repute that academic thinkers did not dare to soil their hands with them. However, if so, the advent of the Freudian psychology changed all this. We are now at liberty to glory in the reduction of benevolent intentions to sexual and egotistical wishes. The present century has witnessed the development of great interest on the part of psychologists in the rôle of instincts and emotions in determining human behavior. The writings of William McDougall upon this subject are representative of the modern psychologist in his most practical mood. We may look for rapid progress towards a really scientific understanding of the forces which drive men to action.

The Pursuit of Happiness Through Psychological Knowledge

In succeeding chapters of the present book, a general doctrine of human motives will be outlined. Its teachings may be anticipated in a general manner in order to illustrate the way in which psychology can conceivably demonstrate the foundations of all practical reasoning. Our doctrine admits that men have many different motives, some of which are inborn and others acquired, but nevertheless there is a general law running through them all. This law is that our tendency to perform any voluntary act is proportional to the total amount of pleasure or "happiness" which we have experienced in connection with the given form of action in the past. It may therefore be said that all of our acts are governed by a *common motive:* our *past happiness.* The motive power of any tendency to voluntary action lies in the sum of our past pleasures (minus the sum of past displeasures).

However, in the intelligent control of human affairs, it appears that *future* and not past happiness must be considered. Although the past furnishes our motives, their realization for which we are now acting lies in the future. Intelligence regulates action with regard to happiness which is to come as well as that which is over. How this is possible we shall endeavor to make clear at a later point in our discussion. In general, we suppose that the conditions for the realization of happiness are the same in the future as in the past; but it is evidently impossible to plan successfully for the achievement of happiness unless we know what these conditions really are.

This is where psychology can enter to render the greatest of all practical services to mankind. Happiness is a property of mind. Psychology is the only science which is concerned with the "conditions" of mind: the factors which determine its nature, and the laws into which these factors enter. What does happiness depend upon? Psychology must provide the answer. Not that we are totally ignorant in regard to this subject. Common sense contains a great deal of true psychology, and the scientific study of mind has already yielded important data regarding the conditions which underlie happiness, as we shall endeavor to show in subsequent pages. Nevertheless, there is still a very great deal more to be learned. Our views concerning the direct physiological basis of feeling are as yet highly speculative. Science can at present offer relatively little assistance to an individual who asks what he shall do to become happy. And yet this is the only practically important question in the whole world of human thought.

Human affairs in the present day involve a vast amount of unhappiness which could be reduced and possibly eliminated by appropriate psychological knowledge. The woes of marital and of martial activity are prominent in this respect. Our methods for obtaining positive pleasure are also quite inefficient. Psychology should be able to guide the author, the dramatist, and the scenario writer so that their productions would be far more pleasing than they average at the present time. Psychology should show the educator and parent how to mold the characters of men in the making so that their habits will fit them for happiness in their necessary relations with nature and their fellow men. Psychology should reveal the kind of social organization which is best adapted to the fundamentals of human nature. In all of its applications, psychology will need the assistance of other sciences, but it must be the leader because it alone can start at the heart of the problem.

Complete Technology

In accordance with the above views, *applied science* or technology is exact knowledge in the service of happiness. Knowledge which is otherwise employed is not really applied. It may be *mis*applied, or enter into humanly meaningless processes. The technology of the present day is *incomplete*. It is incomplete because the reasoning which it involves does not start explicitly with the greatest possible happiness as its determining factor. It usually begins with some material desideratum such as "the strongest possible bridge for a certain price." Complete technology would also be required to determine scientifically whether a bridge at the specified price is in the best interests of human happiness under the given conditions. Under present day civilized procedure, the features of the bridge are computed with refined engineering technique, while the much more important question as to whether or not a bridge shall be built at all is settled by a lottery of opinions in governmental assemblies. A great many other important questions are settled by social convention and law, without any explicit scientific foundations.

This present incompleteness of technology is not due simply to human obstinacy. It is due primarily to lack of knowledge. A balance of opinions provides the only method which is available at present for the making of the most important human decisions. There are no formulæ by which we could compute whether or not we should have declared war upon Germany, and at what time this act should have occurred. Nevertheless, such an act is of vastly more importance than any of the minor incidentals of the war, or other human activity, which are readily amenable to scientific reasoning. The knowledge which is required in order that these broader practical questions should be settled rationally, is psychological. If psychology can find out everything which there is to know concerning happiness and its conditions, there is no reason why such questions should be decided any longer by lawyers and politicians. They can then be worked out by corps of mathematicians and computers with no chance of error or difference of opinion. Then technology will be complete and will carry through from the basic motive to the finest detail of application.

Psychology and Religion

However, we must bear in mind that the use of "happiness" in this statement of the problem is merely illustrative. Psychology has not yet gone far enough to establish the general motive of mankind. It has not even shown that such a motive exists at all. Consequently, what we may call the *prior problem* of technology still remains unsolved. Humankind at the present day is in the sad position of possessing very little scientific knowledge of what it is trying to do in the world. Hence there should be little wonder that the broader aspects of human affairs are extremely muddled. Life has many failures nor do we know how to evaluate its successes. The broader the bearing of a human decision the vaguer and darker its criteria become. We grope in an intellectual obscurity, and seize upon some appealing slogan, as that the "world must be made safe for democracy." Psychology can change all of this if it can finish its task of unravelling "the mystery of mind."

It may occur to some readers that in undertaking a solution of these fundamental practical problems, psychology is trespassing upon the domain of *religion.* It is quite clear, at any rate, that it is dealing with the essential questions of *ethics.* However, who is the real trespasser? Psychology seeks only the truth. Students of religion and ethics purport to do no more nor less. Consequently the psychologist, the moralist and the ecclesiast should eventually agree upon any principles which are capable of real substantiation. We can claim merely that such substantiation must come by the methods of science rather than those of intuition or revelation.

Ethics has endeavored to determine the general principles of "right" conduct. Religion has done more than this in seeking an explanation or foundation for these principles in the nature of an unseen world. Psychology points a scientific way to the knowledge of both of these things. It seeks the "ethical" truths in the fundamental constitution of the human mind. It may find the "religious" truths through a continuation of this research which will lead it to a knowledge of a universe of mind which lies beyond the world of immediate human perception. In this way it resembles the realities of which religion teaches. The human mind is born out of this invisible universe, and its nature and motives must be determined by universal forces. The ultimate roots of ethics and of practical behavior may thus be found in a mysterious "beyond," just as religion has always taught. Yet through psychology we may come to a positive knowledge of these things, in which some of the guesses of the many religions may be verified and others will be proven in error. But now we see these things confusedly through the veil of the "mystery of mind." Psychology can penetrate this veil and show us the way to the greatest possible realization of human potentialities. Let us proceed to a consideration of the mystery and of the factors which are involved in its solution.

CHAPTER II

WHAT IS MIND?

EVERYBODY dislikes a person who uses language without understanding its meaning. Such a person is likely to be regarded as a pretender. Nevertheless, all of us are guilty of this offense in our most commonplace remarks when we employ the personal pronoun, "I." The words, "I," "my," and "mine," dominate our everyday conversation and thought. We cluster about them all of the facts of life: present impressions, memories of the past and hopes for the future. For each one of us the world revolves about these personal pronouns, as if they were a psychological center of gravity. However, in spite of this emphasis in ordinary thinking, scientific students have had great difficulty in arriving at a satisfactory definition of such personal terms. The majority of psychologists have tried to eliminate them from scientific discussions on the ground that they are meaningless.

What is the Meaning of "I"?

If the reader has not delved extensively in psychological lore, he may feel quite confident that he knows the meaning of the word, "I." Let such a reader pause a moment and see whether he can frame a satisfactory definition. It is obvious that any sane person can tell "who" he is, simply by stating his name and his position in society. However, surely no one can believe that his own nature or personal identity is altered by assuming a new name or by a change in social status. Occasionally accident or disease may cause an individual to forget "who he is," in the sense that he becomes unable to recall his own name or to describe his former environment. This occurs in the condition known as *aphasia*, which consists in an almost complete lapse of memory. A person suffering from aphasia may choose a new name and enter into a new set of social relationships. In certain forms of insanity, men indentify themselves with other personalities, which are usually those of famous individuals such as Napoleon or Christ. Yet their fellow-men insist that their actual identity remains unaltered, and social forces are brought to bear upon them to correct their lack of memory.

Thus, it is fairly clear that I cannot define my own nature adequately by stating that "I am John Doe of 128 Main St." This is a definition after the manner of "Who's who." It is admitted that "who is who," that "I am myself," and that John Doe and I are one; but this play of words does not define the term, "I." At most, such considerations merely reveal my arbitrary designation and my temporary position in society. The question which must be answered is not "Who am I?" but "What am I?"

Am I a Body?

The easiest way in which to reply to this latter inquiry is to say: "I am a human being." A human being is a physical body or organism. The nature of such an organism can be specified in great detail by anatomists and physiologists. It is an intricate combination of organs, such as bones, muscles, skin, digestive apparatus, nerves, etc. Each of these organs is made up of living tissues, and the tissues in turn are composed of "cells." The chemist and the physicist can go even further and can tell us the exact constitution of the substances out of which the various parts of the cells are formed. Thus it is possible, even in the present state of knowledge, to present a fairly complete description of the human organism. Now it is evident that there are many such organisms, and hence I may say that a certain particular one among them is "I" or "me."

This conception of myself as a particular human organism seems to provide me with a clear idea of my own nature, and it is a conception which undoubtedly fits many of the cases in which the word, "I," is employed. The "I" which or who resides at 128 Main Street is evidently a physical body. There may be something besides the body, of course, but the latter suffices to make the notion definite. The *name* of this particular body could be tattooed upon it indelibly to provide positive identification. This name might be "I" for purposes of reference by John Doe. For other persons, the name might be "he," or "him." In order to make the designation by pronouns more generally applicable, a number could be assigned to each "I," just as is done with the employees of certain industrial firms, so that different human organisms would be marked: "I1," "I2," etc.

This conception of the human individual as a physical organism is somewhat more acceptable when the pronoun is in the second or third persons than when it is in the first person. It is quite evident to "me" that "you" are a physical body, and it is not evident that you are anything else. If I inquire: "Where are you?" I am satisfied with an answer which locates a particular human body in space. If I ask: "Where did you go last evening?" I am content with a description of the movements of a certain mass of living matter. However, this identification of the individual with the body is much less satisfactory when the pronoun is used in the first person. Woodrow Wilson is reported to have said, as he was dying: "I am a broken machine," but he added: "I am ready to go." The broken machine could not "go," but the real Wilson is said to have "passed away."

The "Self"

The idea that my being is restricted to my bodily existence is usually frowned upon as a materialistic belief which is contrary to the teachings of religion. Hence it is an idea which would be accepted by very few laymen. As a matter of fact, common modes of expression quite frequently exclude this materialistic interpretation. After an accident, a man might say: "I was only slightly injured," in which case the word, "I," would seem to refer to the physical body. However, the unfortunate individual would be more likely to say: "My hand was somewhat bruised," indicating that the injured member is a *possession* rather than being a *part* of himself. In a similar manner, I speak of "my body" as a whole, apparently contrasting it with "myself," to whom it *belongs*.

The distinction between the "self" and the body is made by the most primitive of people. The notion of "self" may be regarded as a general conception, which embraces all of the personal pronouns. However, we must carefully avoid being deluded by the generality of this term. Nothing is added to our knowledge of the real nature of personal existence by substituting a general conception for a group of particular conceptions. We can talk glibly about the self without possessing any proof whatsoever of its reality or any acquaintance with its nature. Many serious students of the subject have emphatically denied the existence of the self, as distinguished from the body. However, an unprejudiced view of the facts indicates that the materialist's doctrine does not account for them all.

There is one serious error against which we must guard ourselves in the very beginning. This error has been committed as frequently by professional philosophers as by laymen. It is the error of defining the self wholly in terms of its supposed relation to the body. If there is a self which is distinct from the body, it must be supposed to act upon the latter and be acted upon by the latter. Hence we may be tempted to define the self as that which is thus associated with a particular body. All that this amounts to is to say that if there is anything immaterial affiliated with the body, we shall call it "the self." This is merely choosing a name. A coroner might gaze at a corpse and state that the murderer was the person who took the victim's life, but this would not provide any real information about the alleged murderer, nor would the statement prove that the case was not one of natural death or suicide. In a similar way, it remains to be shown that there *is* any self which is separate from the body. Is there any real reason for supposing that the living body is not automatic? Why should we assume that it is under the control of some other agency? If there is such an agency, what is its nature?

The Soul

Reasons for believing in an incorporeal self undeniably exist, since such reasons constitute a large part of religious teaching among all peoples. The reasons are somewhat different in the case of "you" than they are in the case of "me," whoever "you" or "I" may be. When I consider my fellow-men I see certain material bodies, and I am informed by physiologists that these bodies are composed of the same chemical elements which occur in some inanimate objects. However, I note that a vast difference exists between the characteristics of living and of non-living bodies. This difference is most marked in the case of human beings but appears also in that of lower animals and even of plants. The distinction between the living and the dead, or non-living, is probably the most striking of all distinctions for primitive thought.

It is natural to seek the cause of this difference in some agency which is present in the living organisms and is absent in the non-living. Common thought has a tendency to attribute any departure from normal conditions to the addition or the subtraction of something from the normal. We feel insecure when we think of letting a change or a condition stand upon its own feet. We like to think of a particular substance as underlying each special feature of the world. We know that it takes coal to operate a steam engine and gasoline to propel an automobile. In a similar manner, the unscientific mind conceives heat and cold as being separate entities which permeate objects in varying degress. Diseases are attributed to the presence in the body of foreign agencies. Science has confirmed this notion in the case of many diseased conditions, by demonstrating the occurence of specific "germs" in the bodily tissues. In the case of temperature, however, a different explanation is given; one which is more like the modern scientific conception of "life." Primitive and unscientific thought, on the other hand, naturally insists upon explaining vital phenomena as due to a substance called "spirit" or "the soul."

Primitive philosophies conceive the soul as the basis of spontaneity in living beings. When the soul separates itself temporarily from the body, as in sleep, there is a temporary cessation of activity. Death, with the complete lapse of spontaneous movement, is explained by the permanent departure of the soul. Each living organism is supposed to be endowed with its own private soul, which is individually responsible for the behavior of that particular organism. Even the seemingly spontaneous activities of inanimate nature, in storm, wind and wave, are attributed to spirits, each having its own special medium of expression. Modern religious teachings have deviated from those of primitive thought to the extent of denying or at least of neglecting the existence of souls in animals, although emphasizing the Diety, as a universal spirit. The possession of a soul is supposed by religion to be a characteristic of all human beings. If such teachings are to be accepted, why should we not say that the true *self* is not the body but the soul?

Before we can adopt this interpretation, we must be sure that we know the nature of the soul and have adequate evidence of its reality. What sort of a thing is the soul supposed to be? It will not suffice to say that the soul is simply the basis of consciousness and activity in living beings. We must be much more concrete than this if we are to have any really definite idea of the soul. Now, primitive religious thinkers actually developed a very definite conception of the nature of the soul. They believed that it was made of *air*, and hence they called it a "spirit," a "pneuma," or an "anima," all of which words refer to an airy substance. This notion of the soul as a being made of air was undoubtedly derived from the observation that living creatures *breathe*, whereas the dead and the inanimate do not exhibit this phenomenon. Thus, for primitive philosophers, the soul was a diaphanous kind of *body*, conceived in somewhat the same way in which the modern scientist conceives a mass of gas.

The progress of both religious and scientific thought has naturally tended to discredit this naïve notion of the soul. The phenomenon of the breath is now explained in a purely physical or physiological way, and physiological principles enable us to understand why breathing ceases at death and is always absent in inanimate objects. Modern religions have followed the idealistic tendency in philosophy and have refused to conceive the soul in any material form, even one so tenuous as that of air. The French philosopher, Descartes — one of the founders of modern ideas — contrasted the soul very sharply with matter, by denying that it is *extended* or can occupy space, as matter always is or does. The essence of the soul, according to Descartes, is to *think*. Yet he does not identify the soul with thought; the soul is only *that which* thinks. The idea of thought, for Descartes, includes all kinds of mental activities. This conception of the soul, like most of its more modern successors, seems to make the soul a mere abstract name of a supposed condition for the existence of conscious life, without providing us with any intelligible account of its nature.

The teachings of Christianity emphasize the *moral* functions of the soul. The soul is frequently represented as endowed with a tendency towards moral uprightness, which is opposed by the carnal appetites of the material body. The moral experiences of the soul are supposed to mould its "character," which persists after death and continues the moral and conscious existence of the individual. Numerous philosophers as well as theologians have endeavored to find in these moral functions an assurance of the soul's reality and its permanence in the event of bodily death. However, a scientific examination of the facts shows that, here again, the soul is merely an abstract term which is applied to a supposed basis of moral development, the real nature of which remains unknown.

Other conceptions of the soul are found in the teachings of spiritualism and of occultism. The modern spiritualists believe that the souls of the dead are able to manifest themselves by producing physical effects, either directly or through the intermediation of a living individual, or "medium." From this point of view, the soul is not so much the cause and explanation of normal as of "supernormal" psychical activity. Many of the so-called "communications" received by spiritualists purport to describe the nature and conditions of the disembodied soul. These descriptions, however, are mainly subjective in character; they give us the impression of a continued, more or less confused consciousness, without specifying the form taken by the individual who is thus conscious. The occultists, following the philosophers of India, have developed elaborate conceptions of multiple planes of existence: the material states of solid, liquid and gas being continued by more and more vaporous substances in a complicated series. Although sophisticated systems of this sort are impressive on account of the care with which they have been worked out, they actually convey no intelligible idea of the nature of human personality apart from the material body.

The Inadequacy of the Soul Theory.

Certain psychologists and philosophers have claimed that we are compelled by logic to asssume the existence of the soul, even if we can form no satisfactory conception of its nature. They have said that our conscious activity inherently implies an acting "substance," even if the latter can neither be perceived nor imagined. They point out that it is very difficult to speak of any mental function without using personal pronouns. The case is similar to that of the æther, in which light and radio waves are supposed to be carried as undulatory movements; if there are to be waves there must be something which *undulates*. If there is to be thought, say the psychological advocates of the soul, there must be something which does the thinking. In modern physics, however, the æther has fared rather poorly, since it has appeared to be merely the unintelligible subject of the verb "to undulate." In the very same way, modern psychology has perceived that the soul is the unknown subject of the verb "to think," and has no other duty to perform. William James, psychologist and philosopher, a man sympathetic with religion as well as with science, wrote: "The soul is at all events needless for expressing the actual subjective phenomena of consciousness as they appear . . . Altogether, the Soul is an outbirth of that sort of philosophizing whose great maxim, according to Dr. Hodgson, is: 'Whatever you are *totally* ignorant of, assert to be the explanation of everything else.'"

All in all, the notion of the soul has proven itself hopelessly inadequate as an attempt to elucidate the nature of the self. If the question: "What am I?" is answered by the statement: "I am a Soul," the question is still open. Such an answer is merely a dignified way of evading the question. If this is true, what shall we do with the question? It is not one which we can set aside, either lightly or with pompous pretense.

Am I a Mind?

Let us ask the psychologist. If there is any scientist who can provide us with the solution, he should be able to do so. However, the psychologist does not immediately make everything as clear as day, for he says: "You are a *mind*." However, we must consider carefully the meaning of the psychologist's answer. All of us believe that we *have* minds, just as we *have* bodies, but it is a somewhat different proposition to admit that we *are* minds. If I *am* a mind, it is incorrect for me to speak of "my mind," since "my mind" is the same as myself. Still, this may be regarded as a legitimate figure of speech, and if we chose to agglutinate the two words into *mymind*, even as we have agglutinated "my" and "self" into "myself," there might be no inconsistency in the use of such an expression. Is the case for the identification of mind with self any better than the similar case for the body and self?

Perfect consistency or truth in the use of words is not to be expected of ordinary, non-scientific discourse. However, if we examine common expressions we find more which are consistent with the identification of the "man" with "his mind" than are thus inconsistent. We say of a person with a deranged mind that "he is out of his head." In the mental state of emotion, one may be said to be "beside himself." When our mental processes depart from their habitual course, we may assert that "we are not ourselves, to-day." On the scientific side there are a multitude of facts which support the psychologist's view that the mind and the self are one and the same. All of the manifestations of the "self" depend upon the mind and change with the latter. If there is any self apart from the mind, it seems forced to operate constantly through a mental medium. Why, then, should we not accept the psychologist's dictum?

What is Mind?

I am a mind, but what is mind? We rejected the claims of the soul, because we could form no satisfactory conception of its nature; and many people would find it easier to define the soul than the mind. Our friend, the psychologist, however, should have no such difficulty, for it is his professional duty to understand the nature and laws of mental reality. We turn to him with confidence that he can give a clear answer to our query.

How sad is our disappointment, when we find that psychologists do not agree concerning the nature of mind, that many define it in terms which are quite unintelligible to the layman, while some even deny its existence. Psychology is the science of mind, but to-day in America psychologists are exhausting their powers of imagination in an endeavor to find out what psychology is "all about." If we reversed the usual process of definition and said that mind is whatever is studied by psychology, we should find ourselves forced to conclude in many cases that mind is merely a special kind of *bodily* activity. The so-called behaviorists among psychologists frown upon nearly all of the customary mental categories, such as sensation, imagination and thought, and insist that psychology is concerned solely with certain functions of the organism. These behaviorists, moreover, are a powerful group in America. Abroad, we find more unanimity, but still a great deal of confusion.

This disagreement among the psychologists need not prevent us, however, from examining the merits of their individual conceptions and selecting a view of mind which seems sensible. The notion that mind is any part of the body or of its activity is ruled out by our previous discussion. We have decided that we, as minds, are distinct from our respective bodies. Although it may ultimately be proven that there is no self except the body, this is a proposition which we are not yet ready to accept. Let us therefore consider some of the definitions or descriptions of mind which have been offered by various individual psychologists.

The most primitive tendency is to define mind in terms of its duties and powers. Thus, Webster's dictionary says: "Mind is that which feels, perceives, wills and thinks." Mind, according to this conception, is the "subject of consciousness," the agency which lies behind so-called mental processes. It is assumed that the existence of feeling implies a capacity to feel, that perception must rest upon a perceptive "faculty," and that willing and thinking are necessarily dependent upon a "power" to will or to think. These various powers are said to reside in the "subject," and to constitute the nature of mind. Probably the most striking of such mental capacities is that of *memory*. Impressions of the past, although not constantly present in consciousness, are nevertheless retained so as to be available at any instant. They are said to be retained in or by the mind. Thus, mind becomes a sort of general explanation of all of the phenomena of consciousness; if it were not for the existence and activity of mind, these phenomena would be impossible.

This view of mind as the ground of consciousness harmonizes very well with our interpretation of the self as mind. "I feel" and "I will" can thus be translated directly into "the mind feels" and "the mind wills." However, the view is subject to the same sort of adverse criticism which we have applied to the doctrine of the soul. Indeed, a careful examination of the view in question leads one to suspect it of being the soul doctrine in disguise. Both the mind and the soul play the rôle of bearers of conscious life. The most which can be said in favor of a distinction between soul and mind lies in pointing out the narrower scope of the latter conception; the soul explains a wider range of facts. However, it would appear that the soul theory originally covered all of the phenomena which are concerned in our notion of mind; so that the idea of the mind as the ground of consciousness is really a soul doctrine with restrictions, pruned of biological and religious implications and intended for purely psychological purposes.

This seems to be an adequate reason for rejecting the idea altogether. If the soul doctrine is vacuous, any refinement of it must be even more vacuous. What is the nature of this thing which feels, perceives, wills and thinks? There are many psychologists and philosophers who are unable to give us any satisfactory answer to this question. They say that they cannot get along without the conception of mind but at the same time admit their inability to describe its nature. However, there are others who conceive the mind in a somewhat more intelligible manner; and we must consider their views before we reject the claims of the mind to be the real self. The opinions which we have previously expressed compel us to disregard all interpretations of mind which identify it with bodily organs or processes.

The Unconscious Mind

One still current doctrine would identify the mind with a so-called "unconscious" or "unconscious mind." This view was advocated at an early date by the philosopher, Von Hartmann, and has been continued by psychologists who are interested in tracing hidden human motives. The conception has proven itself particularly useful in the explanation of certain mental disorders, such as hysteria. The "unconscious" is conceived to be an agency which lies quite outside of the domain of our ordinary consciousness and yet which powerfully influences the latter. The thoughts and impulses which often seem to arise spontaneously in consciousness are supposed to come really from the unconscious realm. The unconscious is thus the actual arbiter of all conscious activities. Many things go on in the unconscious which have no immediate representation in the conscious field, although eventually they will express themselves in a characteristic manner. The structure and functions of the unconscious may be very complex and, in pathological states, the unconscious may even be divided against itself in an internecine struggle, with resulting disorders of consciousness.

The proposal to identify the unconscious with the self harmonizes well with our common notion of the self as the active agency which engineers conscious life. Nevertheless, we are forced to reject the proposal because the advocates of the unconscious fail to provide us with any concrete account of its nature. It seems that they have merely given a new name to the supposed reality which was previously called "soul" or "mind." Possibly the relations between the unconscious and the conscious are conceived somewhat differently from the corresponding relations of "soul" or "mind," but this does not help us to understand the doctrine, save as a modified verbal formula.

An attempt may be made to rescue the conception of the unconscious mind by ascribing to it some characteristic of conscious experience. This was done by the philosopher, Schopenhauer, for example, when he identified the unconscious self with "will." Will seems to be a central fact of conscious life and of the "self," and yet to be something greater than any given concrete experience. It seems to be a controlling agency, persisting through all experiences, linking them together and providing the continuity which is required to make an "individual." If we say that the substance of the unconscious mind is "will" we may feel that we have given the conception a definitely intelligible form.

Unfortunately, modern psychology has not dealt kindly with the notion of "will." The most advanced psychologists eschew the term altogether, while others interpret it in a manner which seems strange to the layman. In common sense and also in traditional philosophy, the idea of will has committed many offenses as a dummy explanation of mental mysteries. Quite frequently, it is set up in renunciation of all explanation, when we account for behavior by acts of will and refuse to look for any underlying motives. The modern tendency in psychology is to explain the "will" (or volition, as a resultant of an interplay between "unconscious" forces) rather than to interpret the unconscious in terms of will. We shall have more to say about this in a later chapter; here we simply note the inadequacy of "will" as a representation of the unconscious self.

The Subconscious Mind

Notwithstanding continued adversity, we need not abandon all hope of finding an intelligible conception of the mind as an agency underlying consciousness. We have still to examine a popular alternative of the *un*conscious, namely the "*sub*conscious" mind. As the term suggests, the "subconscious" is conceived as a true form of consciousness, which is nevertheless removed from the ordinary awareness of the individual, lying psychically "under" the normal consciousness. The subconscious, in this sense may possess any or all of the properties of the conscious realm, except continuity or unity with the latter. Just as my consciousness is separated from yours without either being *un*conscious or necessarily different in kind, so my subconscious may be cut off from my own consciousness and still be of the same general nature as the latter. Just as your consciousness may influence mine, so in even greater measure can my subconscious control the events in my conscious field.

Here, at last, we have discovered a conception of mind which is truly intelligible. Although our idea of the "subconscious mind" may be somewhat vague, it is nevertheless far from being a blank word like "soul" or "will." However, we are not yet out of the woods. We know what we *mean* by the subconscious, but have we any proof that any such a thing actually exists? Some psychologists feel very confident as to the reality of the subconscious, but others deny it without reservation. Nearly all would admit that the subconscious is an hypothesis rather than a fact; its existence cannot as yet be proven, but can only be rendered probable through its capacity to explain the actual facts. Accordingly, if we identify the self with the subconscious we leave it as a problem whether the self really exists. This would be a rather unsatisfactory termination for our search.

Mind in Consciousness

Fortunately, a promising group of possibilities still remains to be considered. We can look for the meaning of mind directly within our *ordinary consciousness.* It may seem an artificiality to have neglected this line of thought for so long, yet in doing so we have followed the natural course of human inquiry, as revealed either in the history of knowledge or in the reflections of any individual, unsophisticated investigator. Consciousness is the most real and certain of all facts, but the last to attract attention. Indeed, it is difficult even forcibly to direct the attention of the layman to the realities of his own consciousness. As popularly considered, consciousness is a subtle and elusive thing, sharply contrasted with the obvious facts of the material world. How many persons who have not made a study of psychology can give a clear definition of "consciousness"? It is a sad commentary on psychological literature and teaching that a good fraction of those who have studied the science are unable to define its subject-matter. Even certain professional psychologists find themselves at a loss to say what they mean by consciousness, and some of them go so far as to doubt whether such a thing exists.

Under such conditions, it seems necessary to consider for ourselves the problem as to the meaning and nature of what is called "consciousness." In doing this we shall be examining one of the most interesting questions which has yet been presented for human inquiry. We shall be reflecting upon a topic concerning which many thinkers entertain the greatest uncertainty, but within which lies the basis of all certainty. We shall be shooting straight for the mark in our quest for the nature of the self. But, more than this, we shall be on the trail of an understanding of the whole world.

CHAPTER III

THE NATURE OF CONSCIOUSNESS

WHAT am I? We have answered: "I am a mind." But what is mind? Again, we have answered: "Consider the nature of *consciousness* and you will find out." So now we must ask: "What is consciousness?" Many different answers have been given to this question by philosophers in times past, and nearly as many are being offered by various psychologists to-day. Let us consider some of them with a view to selecting the best one.

The Constituents of Consciousness

The narrowest of all conceptions of consciousness would identify it with what is sometimes called "self-consciousness." Thus, the British philosopher, John Locke, defined consciousness as "the perception of what passes in a man's own mind," while Reed, another English thinker described it as "that immediate knowledge which we have of all the present operations of our own mind." Consciousness in this sense is a sort of awareness of awareness, a kind of inward bashfulness, in which we perceive ourselves perceiving and feel ourselves feeling. But what about the things which "pass in the mind," and what of the perception and knowledge which we have of facts outside of the mind? Should not some of these also be included in our idea of consciousness?

As a matter of fact, practically all modern psychologists have given up the attempt to restrict the notion of consciousness to the turning inward of mental operations upon themselves. This inward turning is more often called "introspection," and although introspection is a very important activity for the psychologist, it is primarily a method of work and is not essentially the thing which he is working upon. What, then, are the phenomena or facts which the psychologist primarily considers? What are some of the more important "mental operations" or things which "pass in the mind"?

René Descartes, the French philosopher who was a pioneer in so many doctrines which now constitute part of "common sense," asserted that mental activity consists essentially in "thought." In fact, he defined the soul or the mind as a "thinking substance," distinguished in this way from matter, which is characterized by its volume or space-filling nature. Descartes began his philosophy by becoming a universal skeptic, and even went so far as to doubt his own existence. But he reconvinced himself on this important point by means of his famous formula: "I think, therefore I am." Some students interpret this as meaning: "I think, and the thinking is me," but it is more likely that Descartes meant to prove the existence of an entity, the soul, which was doing the thinking.

The conception of thought as the cardinal feature of either mind or consciousness is still a very common one. Common sense inherits that conception very properly from its father, Descartes. Like him, few of us would care to deny the reality of our own thought processes, and we agree with him that our thoughts are distinctly different from the world of matter, to which they usually refer. Hence they seem to be a distinguishing mark of mental life. The modern psychologist also, agrees that thought is a form, or a part, of consciousness, although as a rule he does not accept Descartes' inference of the soul, but insists that "the thoughts themselves are the thinkers" (William James). If we were to accept the view that thought is the *only* kind of consciousness, this would force us to a study of the nature of thought in our attempt to understand the constitution of the mind.

However, no modern psychologist would agree to a limitation of the notion of consciousness to thought alone. It may seem that if we were to stop thinking we would at the same time cease being conscious. In the absence of thought, we certainly could not *judge* ourselves to be conscious, and in this sense we should not "know" whether we were conscious or unconscious. Nevertheless, thought itself will readily demonstrate that consciousness ordinarily has a broader reference. We do not doubt that lower animals are conscious, but it is a serious question whether or not they think. In certain mental diseases people seem to lose all power of thought without apparent loss of consciousness. The problem as to the exact nature of thought is one which we shall be compelled to consider later on, but for the time being we must pursue our quest of the full meaning of the term consciousness.

Another mental phenomenon which has frequently been advocated as an essential, if not the only factor in consciousness is "feeling." Some philosophers have reduced mind exclusively to a bundle of "feelings." A sentient being without feeling seems a contradiction in terms. However, the word "feeling" has been used in a very general and ambiguous manner by many writers upon psychological topics. Sometimes it refers to any simple or elementary part of consciousness, whatever its nature. A more common and definite usage, however, identifies feeling with pleasure and pain, or with the pleasant or unpleasant characteristics of any experience, and more particularly emotional states. It seems easily justifiable to include feeling in this special sense as a part of what we call consciousness. Feeling differs radically from thought, yet it cannot be classed as a physical phenomenon. It may therefore be placed beside thought as a characteristic factor of consciousness.

Concerning the nature of feeling we shall have a great deal to say in a subsequent chapter. Nevertheless, we must recognize here that consciousness includes numerous factors in addition to feeling and thought. Another obvious candidate for admission is "will," with which we frequently associate what we call "effort." The psychologist includes both of these ideas under the general heading of "volition," which consists of those conscious activities which are particularly concerned in the initiation or control of our bodily movements. People ordinarily regard "will" as a peculiar force which can be used to oppose the tendencies of inner feeling or external coercion. The modern psychologist has a different view of the nature of will, but he would have no hesitation in including it as a part of consciousness.

The Internal Sensations

Besides thought, feeling, and will, we must recognize as portions of consciousness a wide variety of phenomena which even the layman commonly classifies as "sensations." There are other related factors which the psychologist regards as sensations, but which the layman usually considers as aspects of the outside world. The latter may be called *external sensations*, while the former may be known as *internal sensations.* Among the internal sensations may be counted pain, in its various forms. Although pain is ordinarily taken as an indication of some physical injury or disturbance in the body, certainly no one regards the pain, itself, as a physical phenomenon. It is, rather, a form of consciousness which arises when these disturbances exist. The psychologist distinguishes between pain as a sensation, and the unpleasantness (or feeling factor) which commonly accompanies it. Pains vary in their nature or quality, according to the locality of the body to which they are referred, as in the skin, in a tooth, or in some visceral organ; and they also vary — more or less independently of their nature — in the degree of their unpleasantness.

In addition to the many different varieties of pain, we may mention numerous other internal sensations, such as fatigue, nausea, hunger, thirst, heart flutter, "the feeling of suffocation," the characteristic "feelings" which accompany a full bladder or an active large intestine, the various phases of sexual sensation, as well as the general "feeling of well-being." All of these sensations are indicative of some definite internal condition of the body, but in themselves they are not physiological but rather are psychological in nature. Sometimes we employ such phrases as "the sensation of nausea," by which we seem to imply that the sensation and the nausea are two separate things. If this view were accepted it would be necessary to add a third thing, namely the actual physiological condition of the stomach. It seems simpler and more in harmony with the facts to limit the situation to two factors: on the one hand the state of the stomach, which is physical, and on the other hand, the nausea, which is a conscious state arising from the gastric disturbance. A third factor may actually exist in our reflection upon the fact of our illness, but this is a *thought* of nausea rather than a sensation. The nausea, itself, is the sensation.

One very important group of internal sensations consists of those which tell us of the positions and movements of our bodies. The psychologist calls them *kinæsthetic* sensations. At first thought, we may tend to confuse these portions of our consciousness with the actual physical postures and motions which our bodies exhibit. A few simple experiments suffice, however, to demonstrate their subjective character, by showing that they can be divorced from the particular physical condition or process with which they are customarily associated. For example, in the sensation known as dizziness we seem to be spinning or falling, when objective tests or observations made by other persons prove that our bodies are stationary. In a similar way, we may receive impressions of muscular position or movement which do not check up with the physical facts in the case.

When we consider the properties of the internal sensations, we find that they differ from one another in several ways. In the first place, they differ in *quality* or in kind. Nausea is a different kind of sensation from fatigue or from sex pleasure, which is another way of saying that these three sensations possess divergent qualities. Secondly, sensations of the same kind may vary in *intensity*. A pain may be slight or moderate or intense, and similar statements may be made concerning any other internal sensation. A third characteristic lies in the *localization* of each sensation in a fairly definite portion of the body. Headache is localized in the head, hunger in the pit of the stomach, and sex sensation in the genitals. This does not mean that we "think" or judge the sensations to be thus distributed; rather, it is a fact of consciousness that they *are*, in themselves and apart from all thought about them, thus positioned.

The External Sensations

When we have added all of the internal sensations, with their properties, to consciousness, we have made quite an important contribution and have arrived at a conception which is very concrete and important. Thought, feeling, will, and the internal sensations constitute consciousness, so far as we have gone. But that is not all, for what about the *external* sensations? If these are not portions of consciousness why should they be called sensations? What are the external sensations, anyway? Here we encounter a problem which it is difficult to treat clearly and convincingly.

We may approach the problem by noting that the internal sensations are not all *equally* internal. A pain in the stomach is more internal than a pain in the finger; and if the latter is caused by the prick of a needle, we may tend to assign the pain to the sharpness of the needle. If we merely take the needle between the fingers, so that it does not injure the skin and thus stimulate a pain nerve, we still have a definite sensation, which is called touch. This we assign very definitely to the needle, since it makes up the hardness and thinness of the latter in so far as we are aware of these properties. Nevertheless, a careful study shows that we have just as much warrant for calling touch a sensation as for classifying pain in this way. Under certain conditions, we may experience touch in the absence of any physical object in contact with the skin. Touch is always associated with the excitation of a definite portion of the nervous system, being impossible in the absence of such excitation, no matter how many objects are present. Similar considerations apply to warmth and coolness which are specialized touch impressions, sometimes ascribed to objects and sometimes to the body.

Having started with touch, the remaining members of the classical "five senses" command our attention. Taste and smell seem to acquaint us immediately with the properties of physical objects. Yet they are aroused only by the excitation of certain sense organs located in the mouth and nose, respectively. Careful analysis shows that there are only four kinds of tastes: sweet, sour, salt, and bitter. Other apparent tastes are in reality odors, sensed through the back passage of the nose, which connects with the mouth. Substances which are taken into the mouth have a much greater variety in chemical composition than is indicated by the four-fold variety of the taste sense. The inference is that tastes represent a response of nerve ends rather than the actual nature of the chemical substances which are concerned. The sense of smell is much more varied, but still there is adequate reason for regarding the odors as sensations rather than as actually inherent properties of objects outside of the body in the physical world.

Here, again, we must be careful to notice that the odor, itself, is the sensation; that the taste, itself, is the sensation. It is meaningless to speak of the "sensation of fragrant," or "the sensation of bitter," for in our actual experience we find only tastes and odors and not anything which is "of" them, except possibly thoughts "about" them.

Tastes seem to reside in the mouth in conjunction with the substances which are "being tasted," but odors usually seem to be properties of the general space around us, or of particular objects outside of our bodies. Because psychologists are persuaded that odors and similar sensations actually depend upon activities going on in the body, and even in the brain, they have sometimes spoken of these sensations as being "projected." They have thought of the sensations as created in the brain and then thrown out into space. But our actual experience is contrary to this idea. Experience reveals to us no process by which odors are projected from within outwards; and outside space seems as good a space for a sensation to occupy as does inside space. If being in outside space prevents an odor from being a sensation, then there can be no doubt that the odor is not a sensation. But other considerations make it quite certain that the odor *is* a sensation, so that being in outside space must be wholly consistent with a sensory character. Internal sensations, as we have noted, have more or less definite positions, and we know so little about the conditions underlying sensation in general that we cannot say — without some experimental basis — that localization must be confined within the bounds of the body.

Localization in outside space is a predominant characteristic of the two classes of sensation which now remain to be considered, namely those of hearing and of sight. Hearing provides us with a wide variety of *musical tones* and *noises*, in multitudinous combinations. Sometimes, as in the case of a cold in the head, we experience illusory tones or noises which are localized within the ears, but as a rule the sensations due to hearing are localized either vaguely or definitely in outside space. This externality is more marked than in the case of smell but less marked than in that of sight. The reasons for regarding tones and noises as sensations, rather than as real properties or activities of physical objects, are just the same as in the case of other external sensations. We shall consider some of these reasons in great detail in ensuing chapters. Tones and noises, as we find them within our consciousnesses, are entirely different things from the corresponding facts which are studied by the physical scientist. As in the case of odors and tastes, there seems to be no ground for talking about "sensations of tone" or "sensations of noise." Tones and noises exist as portions of our consciousnesses, but there is nothing which can properly be said to *possess* them, except the consciousness as a whole, and this is not a sensation.[1]

It is perhaps difficult for the layman actually to regard tones and noises as sensations and as portions of his consciousness. He likes to slip in the seducive "of" and let the tones and noises themselves be parts of the outside physical world, while consciousness retains only the mysterious possessing "sensation of" which no person has ever yet been able to find. The task is even more difficult in the case of sensations due to sight. Here we find the sensations to be definitely and clearly localized in external space so that they seemingly form the most important part of the substance of external objects. The principal visual sensations consist of the *colors*, red, yellow, green, blue, black and white, together with their many intermediate shades or blends. Bear in mind that there is no "sensation *of* red," but only red, itself, which exists to be called a sensation. The red lies on the surface of the red apple, and therefore the sensation is in the same place. The sensation is red and red is the sensation. It is a truly *external* sensation, which never even had to be projected into external space in order to be there.

Although colors are so clearly external in their character, we find that they are actually dependent for their existence upon the properties of the eye and the nervous system. Accordingly, the physical scientist takes no interest in colors, as such, and passes them over to the psychologist to study. This is one reason why we have to regard them as sensations and as integral parts of consciousness. We cannot at this point enter into the details of the relationship between color and the electrical waves which the physicist studies in the place of color. This fascinating topic will command our attention later on, when we come to consider the manner in which consciousness is related to the physical world and the physical body. It must suffice here to class colors as visual sensations and to include them definitely in our conception of consciousness.

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[1] It is possible to give an intelligible interpretation to the use of "of" in connection with sensations, but it would not be conducive to clearness to introduce such an interpretation at the present point in our discussion.

Space Forms in Consciousness

If all colors — including black, white and gray — are to be regarded as elements of consciousness rather than as physical properties of objects before our eyes, the question arises as to whether there are any visible properties of such objects which do not essentially belong to consciousness. What do we find in addition to colors, in an object as we see it? It may be answered that it manifests *spatial* properties, such as definite form, size, and position. It may also exhibit movement. Are these aspects of visible objects also to be classed as factors of consciousness, or are they merely physical? At first thought, without carefully considering the manner in which modern physics deals with space and time, it seems necessary to admit that the forms, sizes, positions and movements of objects are physical in character. Certain it is, at any rate, that physical objects possess these properties.

However, this does not preclude the possibility that the same, or similar features may be manifested by or in consciousness. If we study a seen object carefully we find that its spatial characteristics are essentially dependent upon the way in which colors are distributed in the space before our eyes. An American flag, for example, as we see it, consists of a definite pattern of red, white and blue. The pattern could not be seen, and could scarcely be conceived except in terms of the colors. Of course, the same pattern could be represented in other colors, including a representation in black and white, but in any case some concrete colors would be necessary. It would seem, then, that colors form the fundamental substance of objects as we see them. However, the objects which are considered by the physicist are made of something quite different, namely *matter* or — more ultimately — *electricity*. It is therefore likely that we must distinguish definitely between the *physical* form and the *visual* form. The two may be similar, but they can hardly be identical.

Another way of looking at this problem is to ask how a color can be a part of consciousness, without its shape, size and position being a feature of consciousness also. Colors can exist in consciousness only as definite areas, having definite contours. There is no such thing as a color in the abstract which is "without form and void."

Of course, some color figures, such as a sunset sky, may have diffuse or blurry boundaries, but this does not rob them at all of spatial characteristics. Consequently it seems necessary to admit that if colors are factors in consciousness, their shapes, sizes and distances must also be features of consciousness. This is tantamount to saying that *visual objects*, in all their aspects, are thus included.

External Objects in Consciousness

A similar statement applies to objects, as we know them imperfectly, through (or in) the other senses, such as touch, hearing, or smell. In all cases the object turns out to be essentially nothing but a pattern of sensations, a special and spatial grouping of elements which we have already recognized to be fragments of consciousness. One psychologist (Hunter) says: "By a state of *consciousness* we shall understand anything of which I am immediately aware — a book, a table, a color, a pain, my hate, a joy, a memory, or a thought. On the other hand, no object of which I am at present unaware is a state of consciousness:" Consciousness is thus constituted of objects. Our chief criticism of this definition is of its use of "I" and "aware." The "I" is most easily interpreted as meaning the whole of the consciousness — consisting of the book plus the table plus the color, etc., while the "awareness" stands simply for the coexistence of these things within that same mental combination.

Another psychologist (Breese) says: " . . . the term *consciousness* is used to indicate any and all mental experience; not only the awareness of our own mental states, but also awareness of objects and relations in the outer world." Here we may remain in doubt as to the precise meaning of the term "awareness." If the awareness is conceived as a special mental process or relation which is separate from the object itself, as perceived, then we cannot accept this definition. We do not find any such special awareness; we find only the object itself. Not to be aware of the object can only mean the non-existence of the object in our consciousness. Whether or not it exists elsewhere is of no importance from our present point of view. However, we must constantly bear in mind that the object which we are here considering is one which can be thought of in terms of sensation alone. This is identical with the object of common sense experience, although quite different from that of modern physics as well as of ancient metaphysics.

Space as Part of Consciousness

Objects exist in space. This is true of objects as parts of consciousness, even as it is true of physical objects. It is a precondition of their ability to exhibit spatial characteristics. Shall we therefore conclude that *space* itself is part and parcel of consciousness? Why not? We have already admitted that internal sensations are characterized by definite localization within the body, as experienced. This implies an internal, or bodily space which is a portion of consciousness. The external sensations, in turn, have an even better right to possess an external or extra-bodily space in which they may lie. Space thus appears as a general arena, within which the various sensations are located. This arena is an arena in consciousness. We are not saying, of course, that this space within consciousness is the *same* space which mathematicians and physical scientists consider. That is another question, which we must reserve for future study. But it is the type of space which every common-sense individual knows in his daily life.

A strange conclusion, you may think, which makes consciousness occupy volume, have area, possess size, and share so many features with supposedly physical things. Strange that consciousness should not be confined strictly to the cranium, that it should reach throughout the body, even to its extremities, and then expand into the universe outside! There are many things far stranger than these about consciousness, as we shall see in the sequel. But now, we are simply trying to find out what we *mean* by consciousness, and are not necessarily bound to satisfy all prejudices which may be current concerning its nature. Our problem is to make clear the modern psychologist's conception of the term.

General Definition of Consciousness

Thus far in our discussion we have been endeavoring to build up the notion of consciousness out of the various elements which must constitute it. This should lead to a more concrete understanding of its nature than would the mere formulation of a general definition. However, such general formulations are not without utility. One useful general formula defines consciousness as the reverse of unsciousness. To quote the words of Ladd: "What we are when we are awake, and what we are not when we fall into a quiet dreamless sleep; what we are as we go about our daily work, and what we are not when an overpowering blow upon the head is received that it is 'to be conscious.'" This method of indicating the meaning of the term consciousness evidently leads to a very broad conception, corresponding with the view which we have already expounded. "Quiet dreamless sleep" or the "overpowering blow upon the head" lead to the elimination not only of inward things like thought and feeling, but also of the outward world in its entirety. Just as there are no thoughts in the unconscious state, so there are no houses, trees, earth or sky. Consciousness consists of the whole system which reappears when the individual comes out of the unconscious condition.

As common-sense persons, we believe that the houses, trees and other outside things continue to exist while we are unconscious, although we may admit, after recovering, that our thoughts and feelings actually ceased to exist. We believe that, whereas the inward processes lapsed, the outward realities continued to be, although we were no longer in contact with them. It is this view which leads to the idea of sensation and perception as *relations* between subject and object, as opposed to an identification of the conscious fact with the objects, or their properties, themselves. However, an unprejudiced consideration of the case will show that the individual who has just recovered from unconsciousness has no more proof of the continued existence of the external world during his immediate past than he has of that of his own thoughts. Both may be regarded as "returning" or as being "recreated," whichever we choose. The fact that other persons have been conscious in the interim proves something about their consciousnesses, but nothing about the world which was in ours.

As a matter of fact, the question as to whether the external world of our perception exists when we do not perceive it, has no pertinent bearing upon the conception of consciousness. Consciousness is a compound or mosaic of the various factors which we have enumerated above. Where these factors come from, and how they get compound in the particular manner in which they are given, are interesting questions, but the answer does not affect the definition of consciousness, as such. Red apples and blue skies may come into consciousness from some place outside, but once they are inside of consciousness they are part and parcel of it. On the other hand, it is possible — and even very likely, as we shall see — that all of these seemingly impersonal things of the external world are actually created within consciousness and have no existence apart from consciousness. (See Fig. 1.)

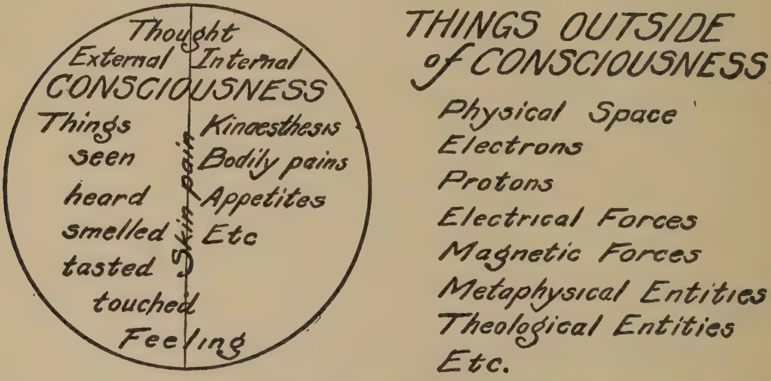

FIG. 1. DIAGRAM TO SHOW THE RELATIONS OF CONSCIOUSNESS TO ITS OWN CONTENTS AND TO OTHER THINGS.

The definition of consciousness which we have adopted makes it include all actual facts of experience, no matter what their character may be. It is only required that the facts should be *actual*. This requirement restricts the facts in question very appreciably when it is rigidly applied. We are constantly thinking and talking and acting about things which are not actual in the sense which is here intended. We think and talk of things which "we remember," or which we have only "heard of." We often act "upon faith." Very frequently we place more reliance upon such vaguely represented facts than upon actually presented ones. But consciousness consists only of the facts which *are now presented*. It consists of all of these facts, but of no others. Thoughts and memories are actual presentations, and hence are important parts of consciousness, but the things or meanings to which they refer usually are not. A great part of our life is adjusted to such absent facts, but consciousness covers a fact only when it is present or immediately "given."

This same insistence upon the concrete immediacy of consciousness necessitates that the idea of consciousness should be confined to the present moment in time. Consciousness cannot be in the past or in the future, but only *now*. It is true that there *was* a consciousness in the past and that there *will be* one in the future; but the past has ceased to exist and the future has not yet come into being, so that the actual consciousness is limited to the present. It is convenient, however, to have a term which includes the past as well as the present — and possibly also the future. Such a term would represent a kind of summation or series of consciousnesses in time: a time span of consciousness. For this purpose, we may employ the word *experience*. Thus, we may define experience as a series of consciousnesses in time, or consciousness as the present moment of experience. Consciousness remains as the only concrete psychological reality, which flows along the stream of time; experience being only its history and its prophecy.

Conscious Individuals

Another peculiarity of consciousness which we must be careful not to gloss over is its individuality. So far as we know, there is no such thing as consciousness at large or in general. All that we know about consciousness is confined to many concrete examples, such as "your consciousness" or mine. Consciousness is not like a vaporous substance diffused throughout the universe. It consists, instead, of a large, but definite number of individual conscious spheres, each of which is more or less sufficient unto itself. Some doubt may be raised as to the real intelligibility of such an expression as "my consciousness," because of uncertainty as to who or what it is which possesses the consciousness in question. However, the expression may be regarded as an easy way of referring to "this consciousness," the one which is "here" and contains "this thinking" which refers to it. "My consciousness" is the Leonard Troland consciousness, which is a particular consciousness distinguished from others, and having its own continuity in time. Moreover, it is associated continuously with the activities of a certain organism and nervous system, which also bear the name of the present writer, just as is the case with the consciousness and organism which is called "yours," gentle reader.

So far as we can tell, each consciousness is "private" and is accessible only to those thoughts which happen to lie within it and form part of it. It is a presupposition of psychology, as the study of consciousness, that each individual must observe and report upon "his own consciousness." This requirement applies just as much to the external world as it does to the internal factors. No one can see the world from your point of view save yourself. It is true that the external portions of consciousness show greater similarity between different individuals who are together than do the internal ones; but the internal similarities are greater between individuals who are geographically separated, than are the external ones. However, even from the same point of view the world is undoubtedly not the same for any two individuals.

Consciousness as the Self

It will be recalled that we were led to study the nature of consciousness by a belief that it would throw light upon the nature of the "self." We recognized that the self could not properly be identified with the soul, the body, or the subconscious mind, but we hoped that we might discover it within consciousness. The individual consciousness and experience do, in fact, provide us with the materials for a satisfactory definition of the self. The broadest definition would be one which identified *consciousness as a whole* with the self; "my consciousness" would thus become a synonym of "my self." Consciousness as a whole satisfies the requirement that it should be something distinct from the physical body (although definitely associated with the latter), yet something which can be demonstrated as a reality beyond peradventure (which the soul cannot be). The individuality of each consciousness and its exclusive linkage with a given physical organism makes it very capable of playing the rôle which is assigned to the self.

However, the fact that consciousness includes so much which seems to be external in character, and which is ordinarily contrasted sharply with the self, may lead us to restrict the idea of the self to a limited section of consciousness. For example, we may identify the self with the *stream of thought* which forms only a small portion of the entire conscious system. We may include, in addition to thought, the internal sensations which make up our bodily experience, and to these we may add the *feelings*. If this view of the nature of the self does not seem sufficiently complete, we may augment it further by means of the notion of the subconscious mind which — now that we know the nature of consciousness — can be conceived more clearly than before.

However, our quest for an understanding of the self has led us into a problem which is broader, and at the same time more definite than the one with which we started our investigation. It is the problem of consciousness and its place in the universe. Consciousness, for the modern psychologist, exemplifies the essence of mind. Although mind may be greater than consciousness in some way, it must be conceived in terms of the latter. In order to arrive at a complete and satisfying conception of the self, we must know more about consciousness and its relations with other things.

Our presentation of the nature of consciousness may have left the impression that no such other things can possibly remain to be considered. If consciousness embraces the external world, as well as the inner facts of our experience; if it includes houses and fields as well as pleasure and pain, what can there be further in the universe to add to it? Is not consciousness the sum total of existence? The idealistic philosopher would reply in the affirmative, but the modern physical scientist would heartily disagree with him. In addition to consciousness, the physicist would say, there exists the great world of *matter*, which is quite a different thing from the world as it is considered by the psychologist. "The mystery of mind" lies primarily in the strange relationship which obtains between the physical world and consciousness. In order to understand this relationship we must first become well acquainted with the *world of modern physics*.

Chapter IV

WHAT IS MATTER?

In the preceding chapter we have seen that the modern psychologist's conception of consciousness makes the latter include a portion of the external world, in addition to inner sensations, feelings and the like. However, it would be an evident mistake to conclude from this that the facts of consciousness exhaust the universe. It is quite clear that, as we ordinarily conceive of the world, only a very small section of it can be considered as embraced within any one man's consciousness. Indeed, it would seem that even if all human and animal consciousnesses were added together, by far the greater portion of the universe would still remain external to them. For example, my consciousness at the present time includes my typewriter, a section of one wall of my library, a window through which appears the façade of a house, some distant trees, a glimpse of a lake through them, a patch of sky, etc. This is a very insignificant part of my own immediate neighborhood, as I ordinarily conceive the latter; and it probably includes nothing at all of the external world which is represented in *your* consciousness at the present instant.

The Physicist's Method

Now the *physicist* is interested, in the first place, in achieving a notion of the world which is *complete*, and is not limited to the meagre glimpses which are alone afforded to the psychologist. Common-sense thinking has a similar interest, although a less thoroughgoing one. Ordinarily our common-sense thought does not lead us beyond the general environment in which we follow our daily routine. But the physical scientist wishes to know the universe in its entirety. In pursuing this wish, he departs from the actual contents of consciousness in a number of different ways. In the first place, he *adds* to his consciousness, so to speak, on the *outside:* making the world of physical science larger than that which is present within consciousness. In the second place, he develops or *subdivides* the world which is actually before him, so as to conceive it as possessing a minute structure which is not immediately apparent within it. Thirdly, he proceeds to *reconstruct* the expanded world which he has thus created, so that its form shall become intellectually satisfactory. We shall consider concrete examples of these three tendencies of physical science below but the net result is that the physicist's world turns out to be something very different from the external world which is present in consciousness.

The physical scientist conceives his universe to be made up of physical substances and forces. These are different from the substances and forces in terms of which the psychologist thinks. The psychologist reduces the external as well as the internal world (of his experience) to terms of sensation; but the physicist says that the world with which he deals is composed of *matter*. What, then, is matter? We cannot be content with the whimsical reply: "Never mind," although we may admit its truth as an assertion. The physicist has been endeavoring for centuries to provide us with an answer to the question, and we can say that at the present he has achieved an admirable success. Although there are still many mysteries concerning the material world, we nevertheless are able to describe its nature very accurately and completely.

Enlarging the World

Let us first consider some ways in which the conception of the physical world has been formed by *enlargement* from the world of direct consciousness. In this connection, we shall also see how the physical world is *reconstructed* to meet the demands of intellectual consistency.

One of the earliest of physical ideas to be developed by men was that of the shape of the earth and of the heavens. As a matter of direct experience, the earth is flat and the heavens are a flattened dome. Men therefore assumed that the universe in its entirety, the part which is beyond consciousness, as well as within it, has the same general type of structure. This assumption involved an extension from experience, but the enlarged world was still conceived in accordance with the pattern found in consciousness. The consciousness of any individual, at any time, was thought of as embracing a restricted section of the total flat earth, and a somewhat larger section of the heavenly dome.

However, numerous other guesses concerning the shape of the universe were hazarded by the ancients. One of these was that the world was really *round* and only *apparently* flat. This conception of the form of the earth was probably derived from an admiration of the sphere as a perfect mathematical figure, rather than from any attempt to explain the motions of the sun and stars. Nevertheless, down to the time of Copernicus and Gallileo, men in general agreed upon the picture of the flat earth and the dome of the heavens revolving about it. Ptolemy and his successors developed this conception in detail and succeeded in explaining a great number of astronomical facts by means of it, although not without considerable complexity of argument. Then came Copernicus, with his dangerous doctrine of a round earth revolving with the other planets about the sun as a center. This doctrine was, upon its face, a direct contradiction of everyday facts of experience. Nevertheless, it proved to be far more satisfactory intellectually than the Ptolemaic view, because it explained perfectly a vast multitude of rare facts known to astronomers, while the rejected view handled them in a bungling manner.

Psychological considerations show how it is possible for the earth actually to be round and yet appear flat. The curvature is so gradual that it falls below the threshold of perception. They also show why only the relative and not the absolute form of the motion of the earth with respect to the heavenly bodies, can be perceived. Even to-day, however, psychologists are still trying to explain exactly why the sky appears as a flattened dome, why — as a matter of consciousness — it undeniably *is* such a structure. Meanwhile, no psychologist and certainly no physicist believes that physically there is any sky surface whatsoever; and every educated person accepts the Copernican theory. Thus, as the physical scientist enlarges his universe, it comes to differ more and more from the world of direct consciousness.

The Copernican doctrine displaced the Ptolemaic because when all known facts were considered, it provided the simpler and the more complete mathematical explanation of them all. It was very far from being a product of immediate observation. When Magellan had actually succeeded in circumnavigating the globe, he was able to piece together the experiences of his successive days and to argue from these facts as to the roundness of the earth. But Columbus, when he sailed west, did not have even this basis of facts for his belief that he could thus reach the Indies. He was acting upon a theory which he had been led to adopt through intellectual considerations.

As the sciences of astronomy and of geography advanced, more and more data accumulated to support the Copernican view. Among these were the three laws of Kepler, which Newton explained by his law of universal gravitation, thus consolidating the system mathematically. Gradually but surely the physical science of astronomy has gone ahead from these beginnings, building up a complex picture of the universe, a picture inspiring in its grandure but dazzling and bewildering to the imagination. We believe with the astronomer that the sun is ninety-two million miles away, and that its diameter is some eight hundred and sixty thousand miles. But in experience it is a small disk the same in size as the moon, both of these heavenly bodies being fastened in the dome of the sky at no very stupendous distance above us. As a matter of experience or consciousness, the sun and the moon are larger at the horizon than in the zenith, yet physically their sizes do not vary.

The stars, as facts in our consciousness, are mere points of brightness in the sky at the same distance as the sun or moon. Yet astronomers tell us that many of them are billions and even trillions of miles away. The light which strikes our eyes at any moment left some of these stars many years ago. This means that the starry firmament which we see to-night represents a physical condition of things long since past. Indeed, owing to the differing distances of the individual stars, it represents a constellation of conditions which never existed simultaneously at all. Evidently astronomy, as a branch of physical or natural science, tells us of a world which lies far beyond our immediate consciousnesses. If we believe in the reality of this astronomic scheme, we must inevitably hold that the astronomic universe is one thing and our "experience of it" is quite another thing. They are undoubtedly connected by intimate ties, as cause and effect, or as premise and conclusion, but they cannot be identical. The one is a world of matter, the other a world in mind.

Subdividing the World

In astronomy, the physical scientist has described a world which eludes our imagination because of its immensity. In chemistry and atomic physics, he has represented a world which transcends experience on account of its extreme minuteness. The idea that seemingly solid or continuous bodies are in reality made up of tiny particles, separated by vacant spaces, dates back to the Greek philosophers. However, until modern times the idea was relatively unfruitful, because it had not been brought into contact with a sufficient variety of facts. Modern physical doctrines concerning the atomic structure of matter have been so successful in establishing such contact as to make the atomic theory quite indispensible in explaining the properties of physical bodies.

The physicist and chemist tell us of many different kinds of physical particles, all of which are far too small to be seen or touched individually. These particles may be ranked roughly according to their sizes. The smallest of them all is called the *proton.* This is a particle of pure *positive electricity.* Next in order comes the *electron,* which is about eighteen hundred times as large as the proton and is made wholly of *negative electricity.* Although the electron is so much larger than the proton, the amount of negative electricity which the former contains is only just sufficient to neutralize the quantity of positive electricity contained in the latter. The two quantities are equal but opposite in kind. Another strange fact lies in the much greater mass of the proton as compared with the electron. It would naturally be expected that the mass of the larger particle would be the greater; or at any rate that the two masses might be equal on account of the equality of their contained amounts of electricity. However, it appears that the greater condensation of the electricity in the proton yields a vastly increased mass. This result can in fact be predicted by electrical theory.

Atoms

It is a fundamental law of electrical science that positive and negative particles attract each other with a force which varies inversely as the square of the distance which separates them. Also, particles of like kind, whether positive or negative, repel each other in accordance with a similar law. Consequently, electrons and protons show a very powerful tendency to combine with or to adhere to one another. The complex particles which are thus formed are known as *atoms*, and sometimes as *ions*. Although there is only one species of protons and one species of electrons, there are many different species of atoms and of ions. This is because the electrons and protons can combine in many different numbers and groupings. When the numbers of protons and electrons in such a combination are equal, the result is called an atom, but if they are unequal it is known as an ion. If there are more electrons than protons in the combination the ion is said to be negative, because the negative particles are in excess. If, on the other hand, there are more protons than electrons the ion is called positive.

The smallest of the atoms is formed by the combination of one proton with one electron. It is the atom of the substance known as hydrogen. The use of hydrogen to fill balloons indicates the fact that hydrogen is the lightest of all substances, existing under ordinary conditions in a gaseous state. Following hydrogen comes a series of atom species which are progressively more complicated and more massive. The most complex and heaviest one of all is called the *uranium* atom. Each of the different atoms consists simply in a union of protons and electrons in definite numbers. The protons and electrons are held together by the forces of electrical attraction which exist between them, but when more than one of each of these particles is involved, forces of repulsion also exist between the particles of like character which must be present. The attractive and the repulsive forces tend to balance each other when the particles are arranged in certain rather definite ways in space, so that each atom has a characteristic structure.

The mass or weight of the uranium atom is about two hundred and thirty-eight times that of the hydrogen atom. For this reason we might be led to anticipate the existence of two hundred and thirty-eight different atomic species. However, if all of these actually exist, some of them must have remarkably similar structures. This is so because the chemist, by the methods available to him, has been able to separate out only about ninety distinct species. The explanation is probably as follows. The protons in an atom are all packed very closely together in the center of the structure. Combined with these are approximately one-half of the electrons, and the resulting aggregation constitutes the so-called *nucleus* of the atom. The nucleus evidently contains an excess of positive electricity, and this has to be balanced by electrons held in the space outside of it. The entire combination makes up the atom as a whole. Now the *chemical* properties of an atom depend upon the number of electrons *outside* of the nucleus, which in turn is determined by the number of unbalanced protons within the nucleus. This latter number will evidently be less, in general, than the total.

Physicists have found methods of determining the exact number of unbalanced protons in atomic nuclei and have concluded that in the uranium atom there are only ninety-two of them. Consequently there can be only ninety-two types or "genera" of atoms which are chemically distinguishable. Nearly all of these have been identified, and each one has been tabulated by the chemist as corresponding to a specific *chemical element.* A single chemical element therefore consists of atoms, all of which have the same number of "external" electrons. Such atoms, however, may have different numbers of electrons and (balanced) protons in their nuclei. Atoms or substances which differ in this manner only are called *isotopes.*

Radioactivity

Although chemists used to think of atoms and elements as ultimate and indestructible, it is now known that they are only relatively so. In processes of chemical change and under other circumstances the external electrons of the atom may be reduced or increased in number, forming positive or negative ions, respectively. In the process known as *radioactivity* even the nucleus breaks up, forming atoms different in kind from the original ones. Among the atoms thus formed, the helium atom is the most common, so that it seems likely that this atom forms one of the structural units of the nucleus in atoms more complicated than itself. Speaking more exactly, it is the helium nucleus which appears in radioactivity, since it is lacking in the two external electrons which are present in the helium atom as a whole. Helium is the second lightest of the chemical elements, and its atomic nucleus seems to consist of four protons plus two electrons. (See Fig. 2.)

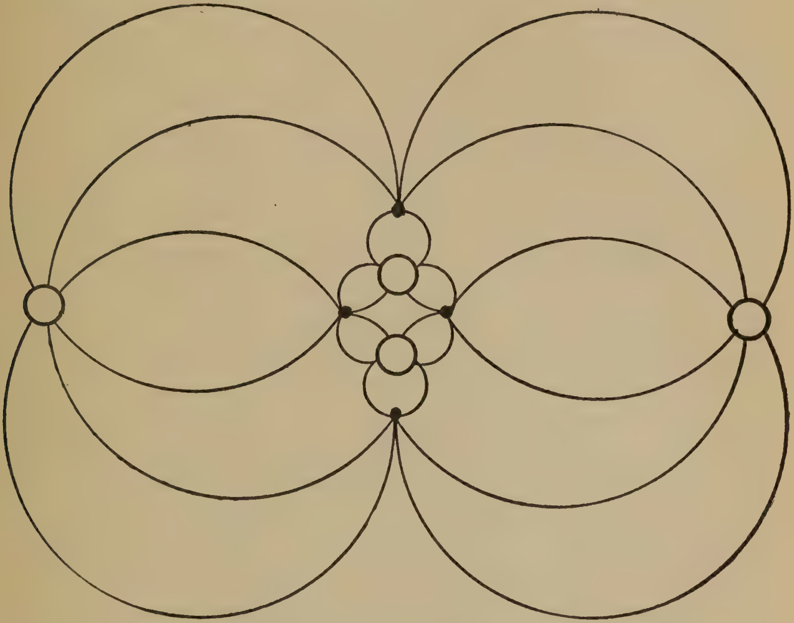

FIG. 2. IMAGINARY DIAGRAM OF STRUCTURE OF A HELIUM ATOM.

The small dark points represent protons, while the larger circles stand for electrons. The connecting lines represent the electrical fields between the particles. No attempt has been made to make this diagram show the actual proportions of the structure.

The atoms which disintegrate radioactively are amongst the most complex and massive ones, indicating that as a nucleus increases in size it decreases in stability. This is probably because the attractive forces are no longer able adequately to overcome the repulsive ones. It is for this same reason that atoms more complex than that of uranium are impossible. When an atom nucleus breaks up, a very large amount of energy is liberated; that is, the amount is very large compared with any energy which can be obtained from the external electronic structure. This energy is mainly manifested in the extremely high speed with which the helium ions are shot off from the disintegrating nucleus. In some cases, however, electrons are expelled instead of helium ions. These moving particles are called alpha and beta rays, respectively. Still a third form of energy is present in the so-called gamma rays, which are not particles, but wave disturbances similar to light.

Electromagnetic Waves

The manner of origin of these wave disturbances is worthy of special consideration. They are to be regarded, in the first place, as effects incidental to the discharge of the electrical particles from the nucleus. General electrical theory demands that when such a particle is speeded up or slowed down, there should be a distortion of its so-called *fields of force*. Of these fields there are usually two, the electric and the magnetic. The former represents the tendency of the electrical particle either to attract or to repel another particle, according to its "sign" (positive or negative). The latter represents the tendency to attract or to repel a magnetic "north pole." The magnetic field exists around an electrical particle only when the particle is moving, and magnetic "poles," whether "north" or "south" are created only by such motion. When the electron or proton or ion moves steadily the two fields are also steady and undistorted. When, however, the motion is increased or reduced there is a distortion or strain set up in the fields, and this disturbance is propagated away from the particle at the tremendous speed of one hundred and eighty-six thousand miles a second: "the velocity of light."

The generation of such "electro-magnetic" disturbances is not limited to radioactive changes, but occurs wherever electrons or other electrified particles alter their speeds or directions of movement. X-rays, light, radiant heat, and radio waves all belong in the same class with the gamma rays from radium. They differ primarily only in their wave-length or frequency, which is determined by the quickness of the speed-changes upon which they depend. At one time physicists believed that such waves existed only in a space-filling medium called the æther, but nowadays the tendency is to explain them in terms of the electric and magnetic fields, without reference to the æther. The existence of the æther has been rendered very doubtful by the development of the "relativity principle" of Einstein, discussed below.

Chemical Action

The structure of an atom is frequently so open-work in nature that the forces associated with the electrons and protons are able to reach outside of the individual atom to some extent and bind two or more atoms together. Such a union of atoms is known as a *molecule.* The processes in which molecules are formed or broken up are known as *chemical changes.* A collection of molecules, all of the same kind, constitutes a pure chemical compound substance. Although there are only ninety-two possible chemical elements, the number of pure chemical compounds is limited only by the possible combinations of the ninety-two genera of atoms. There is an almost infinite variety of such combinations, although they are all subject to definite rules. Some atoms show a much greater diversity in their combinations than do others. Carbon, the element at the basis of life processes, is the most versatile of all. This is probably due to the especially open-work character of its atom structure. Other atoms, such as those of helium, refuse to enter into any chemical combinations whatsoever.

The residual forces which bind atoms together to form molecules are known as forces of *chemical affinity*, although they really are of the same kind as those which unite electrons and protons into atoms. It is easily appreciated that these forces will be determined mainly by the electrons which are outside of the nucleus, so that all chemical properties will be determined by the numbers of these electrons which are present. Molecules possess definite structures, or arrangements of their constituent atoms in space. When the molecular structure varies, even if the number and identity of the atoms remains unchanged, there is always some accompanying change in the properties of the corresponding substance. Chemical changes are of three general kinds: combination, disintegration, and rearrangement. Combination is usually due to the inherent forces of attraction existing between the atoms. Disintegration ordinarily rests upon the action of outside disturbing forces, such as heat.

Heat

Heat, according to the modern physical view, consists in a random vibratory movement of the molecules and other particles — such as electrons — of which any body is composed. The more rapid this vibration, the higher the temperature. The vibrations are still very energetic in bodies which seem to be very cold, and are only absent at the excessively low temperature of two hundred and seventy-three degrees below zero Centigrade. Since this temperature has never yet been produced on the earth's surface, we can say that all bodies with which we are acquainted carry some degree of heat. The sharp distinction which we commonly make between "hot" and "cold" has a psychological rather than a physical basis. The sources of increased heat are always found in some process which speeds up the molecular vibration. An example is to be found in a chemical combination such as the burning of coal, where the molecules are agitated by the chemical affinities which come into play. The collisions which are continually occurring between moving molecules tend to level out local differences in vibratory speed or temperature, and bring all parts of a body to the same temperature.

Solid, Liquid And Gas

Molecules combine with one another to produce the large masses of matter which we find represented in our everyday experience. The loosest form of such combination is a *gas*, in which the molecules are separated by relatively enormous empty spaces. In a gas the energy of the heat vibration is greater than the attraction of the molecules for one another and therefore keeps them apart. In the *liquid* state, however, the attraction overcomes the heat energy, so that the molecules fall together into a closely packed mass. The attraction is still insufficient to prevent the individual molecules from sliding by one another, so that the mass is highly plastic. In the *solid* the further relative increase of the attractive forces renders this sliding action impossible, so that the total mass possesses rigidity. The forces which thus hold the molecules together are to be regarded as derived ultimately from the fundamental attractions existing between electrons and protons. They are, so to speak, secondary residues from chemical affinity. However, in the case of crystalline solids, there seems to be no clear distinction between the forces which bind the atoms and those which unite the molecules; in a sense, the crystal is a single huge molecule.

Electric Currents

Among other properties possessed by aggregations of molecules is the especially interesting one of ability to carry an electric current. Such a current consists in an actual flow of electrons or else of ions through the substance. In the case of solids, such as metals, the current consists entirely of moving electrons, but in liquids (except mercury) the motion is one of ions, and hence involves in the latter case an actual transfer of chemical substances. The ions in a liquid are usually due mainly to dissolved substances, the molecules of which tend to break up into oppositely charged parts in the presence of the liquid molecules.

Life And Biology

A solution is an example of a chemically impure or complex substance. Such substances, consisting of mixtures of various kinds of molecules, frequently exhibit properties different from those of any of the individual substances which are thus combined. Thus an aqueous solution of salt conducts electricity readily, whereas both pure water and pure salt conduct practically not at all. Protoplasm, the general substance from which living organisms are constructed, manifests this principle in its highest form. Protoplasm is probably the most complex of all naturally produced substances, so that its properties are very intricate. Practically any of the powers shown by protoplasm can be demonstrated in separate simpler substances. Protoplasm is unique only in combining them all in a single body. This combination itself produces new characteristics due to the manner in which the united properties influence one another. This coöperation of properties is sometimes called *organization.*

At one time, biologists believed that some special agency — not found elsewhere in the physical world — was involved in *life*. One or two biologists, and a larger proportion of other types of scientists, still seem to hold to this view. They speak of "vital force," "entelechy," or the like as something which cannot be explained in terms of protons and electrons. However, an overwhelming number of scientists — including practically all biologists — now believe that life can be reduced to a very complex interplay of the same forces which underlie the facts of physics and chemistry. In other words, they regard biology — the science of life — as a strictly physical science. The seemingly vast gap which exists between living and non-living things is held to be due to a correspondingly great difference in complexity, rather than to any fundamental difference of substance.

In regarding biology as a purely physical science, biologists perforce admit that the science is very far from being complete and perfect at the present day. Since the complexity of living bodies is so very great, it must be a long while yet, before we can understand all of their details in physical terms. So long as certain phenomena remain unexplained, skeptics are quite at liberty to assert that they are inexplicable. But this does not prevent the physical biologist from continuing his effort to account for them in the terms which he has chosen to employ.

One fundamental question which faces the biologist is how living bodies have acquired their great and specific complexity. Protoplasm builds itself up into the intricate machines which we call human, animal or plant bodies. These bodies are so constructed as to be able to maintain their existence over considerable periods of time in the face of serious obstacles. Although they may ultimately fail as individuals, they nevertheless reproduce their kind and may survive indefinitely as species. The biologist sees no reason why these things cannot be accomplished by purely physical means. He must admit, however, that the means do not develop instantaneously out of the nature of protons and electrons. He acknowledges that the powers of life have been developed gradually during a vast period of time in the past, in the process known as evolution. Time has been the builder of life. But the materials with which time has worked have been purely physical. All matter, non-living as well as living, has had its evolution, in which the fittest have survived and the unfit and unstable forms have disappeared. Hence, as Darwin recognized, whatever continues to exist, whether it be complex or simple, must necessarily be *fit* or it would long since have perished.

When the biologist speaks of explaining life wholly in a physical way, he has no thought of including the phenomena of *mind*. The biologist, as such, knows no psychology. It is no part of the biologist's task to explain the existence of thought, feeling and sensation in association with organic activities. He does not deny their existence; he simply ignores it. He must do this because thought, feeling and sensation are not reducible to physical terms, so that to have recourse to them would be to depart from the biological faith. Furthermore, he does not find it necessary or useful to employ psychological conceptions. It is true that the biologists must account for human and animal behavior, a problem which also interests the psychologists, but the biological account will still be given in physical terms, as if men and animals were pure machines, without consciousness in any form.

Is the Physical World in Consciousness?

When we reflect upon the minute structure of the world, as it is described by the physicist, we see that he is talking of something very different from the world in our consciousness. There are no molecules, no atoms, no electrons, and no protons in the world as we see it and touch it. There are none of the minute structural arrangements or movements of these particles which physics depicts. On the other hand, the world of physics has no colors, no cold, no odor, or few if any of the sensible properties found in the world of consciousness. It is quite evident that the world as we perceive it and the world as described by physical science are far from being identical. Indeed, if they were identical the physicist could have arrived at his conclusions with very little labor. The question may legitimately arise, however, as to whether the two worlds do not have *some portions in common.* It would seem, for instance, that the space of the physical world and that of external sensation may be identical, and that the shapes of large objects are the same in both systems. *Time*, also, would appear to be in common.

The problem thus introduced has been a topic of philosophical discussion throughout the ages, but modern physical ideas throw considerable light upon its solution. In fact, they indicate a decisive answer. We refer to Einstein's "principle of relativity," which is a physicist's own study of the time and space and mass of the physical world. It has been the effort of physicists for a long time to express all of their ideas mathematically in terms of space, mass and time. Other conceptions, such as force and energy, were reduced to definite combinations or relationships of these three fundamental factors. For example, force reduces to mass multiplied by space (length) divided twice by time. The fundamental factors or "dimensions" have their characteristic "units" of measurement. Thus, space or length is measured in centimeters, mass in grams and time in seconds; the scheme as a whole being known as the "C. G. S. system" (for the centimeter, the gram, and the second.[1])

The Relativity Principle

Now, Einstein set out to study the conditions under which physical measurments are made. He also wished to see whether certain hitherto unexplained facts could not be accounted for on the basis of a proper understanding of these conditions. The facts in question have to do with the physical effects to be expected as a result of the earth's motion through space. Einstein found it possible to develop the explanation for which he was looking, if he supposed that physical units of measurement vary in apparent magnitude when made upon a body which is moving. The faster the motion, the smaller the units of length and time, and the larger the unit of mass. Thus a physicist upon the planet Mars, as it passed rapidly by the earth, would appear to us to be employing erroneous units; although if Mars were to stop relatively to the earth, the units would be automatically corrected. However, the Martian physicist could make exactly the same statements about the units which were being employed by the mundane physicist, while regarding his own units as correct even while his planet was in motion. The motion, however, is *relative*, so that the Martian's claim to correctness is exactly as good as the earth-dweller's claim. The two claims, however, are mutually incompatible if space, time, and mass have the characteristics which are ordinarily attributed to them.

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[1] It is true that discussions of electricity and magnetism have introduced two other factors, characteristic of the electrical and of the magnetic fields, respectively; but we may neglect these for the present.

It is impossible to attempt a real exposition of Einstein's theory here. What has been said above is intended only to indicate that the modern physicist has been forced by intellectual processes to a view of the fundamental dimensions of his world which makes them quite different from the corresponding factors of common experience. Physical space and time, although correlated in some way with the space and time of consciousness, cannot be identified with the latter. A similar conclusion can be reached by approaching the problem from the psychological side. Space as we see it or feel it has properties which even the old fashioned physicist ruled out of physical space. Psychological space has a built-in point of view, a perspective character, which is indicative of its dependency upon the individual observer. Psychological time varies in its relation to physical time, sometimes moving more rapidly, sometimes more slowly. Psychological mass reduces to sensations which have no resemblance to the physicist's conception of mass.

The Separateness of Physical and Psychical

In the light of the above considerations, it seems necessary to go the whole way and to say that the world of modern physical science and the world in consciousness have *no common parts at all.* They do not really intersect anywhere. The physical world is one thing and the external world which we "see," "touch," "hear," "smell" and "taste" is quite another thing. The conscious world is made of sensation and subjective space and time. The physical world is composed of electricity moving in a different sort of manifold. We do not know what electricity is in terms of consciousness, and we cannot imagine the nature of the Einstein system. The best that we can do is to handle the mathematical equations which describe these mysterious physical entities.

Nevertheless, there must be some *relation* between the physical world and the world in consciousness. Yes, indeed, for the physicist starts with his consciousness when he initiates his far-flung reasoning. He comes back to his consciousness, again, every time he actually applies or tests a theoretical result. Spots of light on a vacuum tube wall have meaning for the physicist in terms of electrons, but as "spots" they are visual sensations. Similar statements can be made concerning every other so-called "physical observation." But, we can go much farther than this. The physiological psychologist knows that sensations and objects in consciousness have a relation to special physical processes, those of the individual body. Even thought, feeling, and will have their physical counterparts. In other words, although we cannot identify *any* part of consciousness with any part of the physical world, we must admit that *every* part of consciousness stands in a definite relation to *some* part of the physical system. To consider the essentials of this fascinating relationship will be the topic of our next chapter.

CHAPTER V

THE INTERRELATIONS OF CONSCIOUSNESS AND MATTER

BEFORE we attempt to analyze the relations which hold between consciousness and matter let us review briefly what we have learned concerning the inherent natures of these two contrasted things.

We found that consciousness exists in the form of separate individual systems or spheres, such as "your consciousness" or "my consciousness." "Your consciousness" is made up of all of the things which "you" are ordinarily said to be "conscious of." It consists of thoughts, feelings, will, internal sensations, external sensations, objects as perceived, and even experienced space and time. We denied, however, that the "you" and "your" have any meaning outside of this consciousness, itself; we looked *inside* of consciousness for the meaning of these terms. Moreover, we denied the importance of the preposition "of" in the phrase, "consciousness of," and regarded consciousness as an entity, a system, or a substance, rather than as a relation or activity. Looked upon in this way, consciousness presents a similarity to a material object such as a machine. It has a definite *structure;* it is a compact and definitely organized combination of *parts* which work together in a characteristic way. The parts are the various things which we find within it, thoughts, feelings, sensations, etc. The exact nature and arrangement of these parts varies from time to time in the same consciousness, or from one consciousness to another. They are always characterized, however, by their *qualitative variety*, as red differs in quality from green, or pain from sweetness.

When we came to consider the physical world, on the other hand, we found that in the place of isolated individuals, we had to deal with a vast, impersonal universe. So impersonal is this universe that it employs none of the parts of consciousness in its conception. Although the physical system exists in a sort of space and time, these are "according to Einstein" and thus very different from the space and time which are found in consciousness. Moreover, the parts of the physical world are not continuous with one another like those of consciousness, but consist in minute grains of positive and negative electricity. Electricity is known only through its behavior, and the distinction between its positive and negative kinds is apparently not representable in conscious terms. The whole physical world is a tremendous mosaic of electrical particles, and except for the forces, energy and motion which attach to these particles, there is nothing else whatsoever to be found within it. It has no "qualitative variety" such as exists in consciousnesses; its variety is wholly *structural.*

The various structures which exist in the physical universe follow a natural order of arrangement depending upon their complexity. First comes the atom, then the molecule, then the molar mass, and finally: living organisms, some relatively simple and some very intricate in form and activity. The most intricate of all physical structures is the one known as the *human organism.* But "human" though it may be, it is nothing but a very complicated constellation of protons and electrons, with their associated forces. At any rate, this is the way in which the biophysicist or physiologist conceives of its nature. Nevertheless, the psychologist knows that active — living and waking — human organisms "are conscious." At least, they *have* consciousnesses; or, more strictly speaking, there *exists* a consciousness *corresponding to* each of these waking organisms. If we wish, we can say that the consciousness *belongs* to the organism as a piece of private property. It would be equally legitimate, however, to say that the organism belongs to the consciousness. One thing is certain, that the consciousness does not *reside* in the organism nor is the organism present in consciousness.

The Relation of Internal Sensations to the Body

Still, the organism apparently has a *representation* in consciousness. It gains this, in one way, through the *internal sensations*, and through some of the *feelings*, and even through some aspects of "will." The internal sensations indicate or signify the form, the posture, the movement and condition of the living body. Yet they cannot be identified with the latter as a physical structure. Pain tells us that our tissues are being injured, but pain is in itself absolutely different from the injury. Neither can the movement sensations which accompany walking, be identified with the physical displacement of the limbs or of the body as a whole. Nevertheless, the relation between these things is fairly definite and constant. When the tissues are injured we normally have a pain in consciousness and the nature and localization of the pain depends upon the location of the injury in the body.

The general proposition which seems to be true regarding the relation of the internal sensations to the physical body, is that the former *correspond* to the latter. However, there are many fewer sensations than there are parts and conditions of the body. In a state of health the internal sensations occupy a minor place in consciousness. There is a general "feeling" of the body as a whole combined with a clear representation of its given posture or movement, but internal organs, such as the stomach or lungs have no definite sensations to represent them. Consciousness is mainly composed of external sensations, since in the state of health our chief concern is with the world about us. However, in illness consciousness may be dominated almost entirely by internal sensations. But usually these do not represent the organism as a whole, as they tend to stand for some particular organ, such as the stomach, which is in a disordered state. It would appear, therefore, that the correspondence which exists between the body and the internal sensations is not only incomplete, but is variable.

When we think about our internal sensations in a careless manner, we tend to identify them with the physiological conditions which they represent. However, as soon as we recognize that the two things are quite different, the question arises as to the basis of the actual correspondence which exists between them. Why should there be any definite relation at all between consciousness and the state of the body. We may say that it is in the nature of consciousness to represent the bodily condition, but his statement gives us no real insight into the matter. We must inquire whether there is any special apparatus or any special conditions which *engineer* the internal sensations.

The Part Played by Nerves

When we make such an inquiry we find at once that *nerves* are involved. In order that we should have the undesirable internal sensation known as a tooth-ache or as dental pain, there must be a nerve in the tooth. Moreover, this nerve must be *stimulated* or excited, as by the chemical action of sugar or the heat generated by the dentist's drill. Sometimes the decay of the tooth is so bad that the dentist has to remove the nerve, and thereafter no amount of sugar or heat will produce the pain. The pain is also absent when the tooth is whole, or not subject to forces which excite the nerve. There is a further way in which the pain can be avoided, and one which the dentist frequently utilizes. This consists in paralyzing the nerve with a drug, such as cocaine. Usually, however, the dentist does not apply the cocaine directly to the tooth, but instead he injects it into the gum at the proper place. In this case a number of teeth and also the surrounding gum are rendered insensitive to conditions which would otherwise result in severe pain. (See Fig. 3.)

These facts show clearly that the pain sensation does not correspond simply and directly to the abnormal condition of the tooth. In order that this condition should be accompanied by pain it must first arouse the nerve to activity. It would therefore appear very probable that the pain is due to the nerve activity and not directly to the condition of the tooth. However, in order to prove that the latter does not play an essential part, we must show that pains which are localized in the tooth can be aroused by nerve activity alone. This can be done in several ways. In the condition known as dental neuralgia, pains are experienced in the teeth which can only be explained as due to irritation of the nerves, since the substance of the tooth is intact. Another case appears in cauterizing certain portions of the inner membrane of the nose, during which process tingling sensations are frequently had in the teeth. These are referable to the stimulation of nerves coming from the teeth and passing close to the nasal membrane which is under the influence of the cautery.

It is to be noted that regardless of the exact manner in which the nerves are stimulated or paralyzed the effect is always referred to the *tooth.* When the dental nerve is excited through the nasal membrane the sensation is not "in the nose" but is "in the tooth."

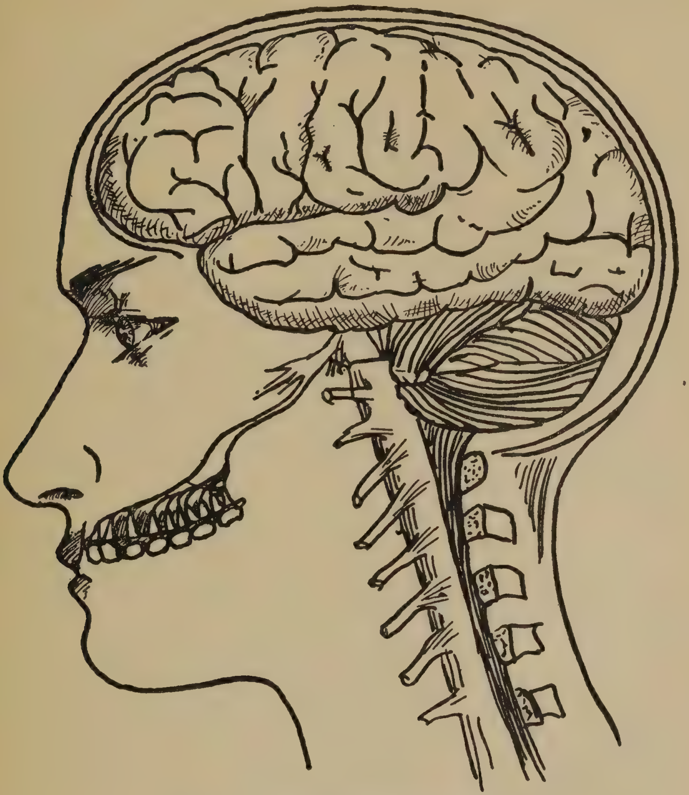

FIG. 3. THE DENTAL NERVE PATH.
Diagram to show the relations of the teeth and their nerves to the brain. See text.

When the nerve is paralyzed the *tooth* becomes numb. The nerves are apparently not represented in consciousness on their own behalf. There is scarcely any instance in which a sensation is consciously referred to a nerve. Indeed, it is only through scientific instruction that the layman learns to think and talk about nerves at all. The fact that sensations tend to be localized at the points where nerves begin, and frequently in advance of these points, presents one of the fundamental problems in the "mystery of mind."

We have considered the case of dental pain as an illustration. The statements which hold for it are also valid for all other internal sensations. For each of these there is a corresponding nerve or group of nerves, and the sensation is associated with the activity of a specific nerve rather than with the bodily condition in itself. Thus, the sensations corresponding to bodily postures and movements depend upon nerves ending in the muscles, joints, tendons, and the sense-organs of the internal ear. There are many different kinds of organic pain, each of which has its own peculiar nervous basis. The sensation which accompanies a full bladder is due to the excitation of nerves ending in the wall of that organ. The general principle that the nature of a sensation depends upon the particular nerve which is involved, rather than upon the conditions of its excitation, is known as the doctrine of "specific nerve energy," and was formulated many years ago by the German physiologist, Johannes Müller.

The Nature of Nerves

When we speak of a nerve, we involve ourselves in the consideration of a complex piece of apparatus. In its simplest conception, a nerve is a fine, conducting thread which connects the sense organ with the so-called "central nervous system." However, there is another class of nerves which join this latter system to the muscles and glands of the body. The first kind of nerves are called "sensory," while the second kind are known as "motor." When they are studied through a microscope these two species of nerves show no very marked differences. Nevertheless, the relations which they bear to consciousness are radically different. The activity of the sensory nerves results in sensation, while that of the motor nerves is responsible for bodily movements and postures. We shall have more to say later concerning the relationship between the activity of the motor nerves and what transpires in consciousness. Our present concern is with the sensory nerves.

Let us consider further what is meant by the statement that "a nerve is a conducting thread." The pain nerve of a tooth is a delicate fibre which has numerous branches interlacing with the blood vessels of the core of the tooth. This fibre extends through the roots of the tooth into the jaw and thence to the stem of the brain. When the decayed tooth is acted upon by an irritating substance a change takes place in the nerve at the point where the action occurs and this change travels along the fibre to the brain. More strictly speaking, the disturbance of the nerve at the tooth brings about a disturbance at the next point removed from the tooth, and this in turn is passed on to a further point until finally the brain is reached. The nerve in the disturbed state is said to be "excited" and the exciting agency is called the "stimulus." The passing on of the excitation from the tooth to the brain is known as "the conduction of the nervous impulse." The conduction has a definite speed, which is approximately at the rate of three miles a minute. This is about one third of the speed at which sound travels through air and less than one three-millionth the velocity of radio or light waves.

Usually a sensory nerve is provided at its outer end with a special attachment for picking up the action of the stimulus. This attachment is called a "receptor," because it *receives* the stimulus, and its function can be compared with that of the tuned circuits in a radio receiving set. It renders the nerve particularly sensitive to certain classes of influences and relatively insensitive to others, just as the tuned circuit favors a given wave-length. Thus pain nerves are sensitized to stimuli which threaten the tissues, while taste nerves respond to definite chemical substances and the nerves of the eye react primarily to light. In the absence of such specialized receptors the nerves are comparatively insensitive to the majority of these agencies and show no marked differences in their sensitivity to a given agency. Receptors are frequently grouped together in a systematic way and surrounded by other living tissues to form a *sense-organ*, such as the eye or ear.

The individual nerve *fibre* itself is so very fine as to be entirely invisible to the naked eye. However, many thousands of these fibres are ordinarily bundled together to form what is commonly called a "nerve." Within this bundle the individual fibres are *insulated* from one another, so that conduction started in one fibre never spreads to its neighbors. The arrangement resembles that of a cable of telephone or telegraph wires. The main substance of the fibres consists in a watery solution of salts and organic matters, while the insulating coating has a fatty composition. When the fibre is in an unexcited state it carries an electrified layer all around just underneath the insulation, but when excited this layer is partially and temporarily destroyed. We shall have more to say later concerning these interesting electrical phenomena which are manifested by nerves.

Sensation and the Brain

To return now to the problem of internal sensation, it will be recalled that this was found to demand the presence and activity of a sensory nerve. The activity in question involves excitation and conduction, paralysis of the nerve — as by cocaine — rendering both of these processes impossible. Conduction is an activity which leads away from the tooth, or other sensitive ending, towards the brain or spinal cord and eventually stops at some definite terminus. Hence we are impelled to ask *how far* the conduction must go in order to make the sensation possible. The situation is such that we are tempted to answer that the conduction must proceed as far as *consciousness*, as if consciousness were located in some definite portion of the body. However, we must be careful to avoid such an answer as this, since consciousness is not the kind of a thing to be located anywhere within the physical organism. Nevertheless, there may be some part of the body which acts "as if" it were the "seat of consciousness."

In order to determine how far the conduction must proceed before the sensation is possible, we can try the experiment of cutting or of paralyzing the nerve at different points along its path. The results show that interruption of the nerve activity anywhere between the receptor and the *brain* has the same effect: there is no sensation no matter how good the stimulus. The pain nerves from the middle and lower regions of the body connect first with the spinal cord, a very heavy nerve cable which is encased in the body vertebrae of the spine. They reach the cord in smaller bundles which also carry nerves of touch and temperature. However, within the cord all of the pain conductors are grouped together in a channel which is separate from that carrying other nerve impulses. Thus, they pass up the cord to a portion of the brain known as the "thalamus." Now, if a nerve bundle is cut in advance of the cord there is loss of all three forms of sensation — pain, touch, and temperature — for a restricted portion of the body surface. But if the pain path in the cord is interrupted, anywhere from the entrance of the nerve up to the thalamus, pain alone disappears; although just as completely as if the interruption were in the earlier sections of the conducting system.

We must conclude, therefore that pain sensation is only possible when certain portions of the brain are set into activity. We may still inquire, however, whether the brain activities alone are sufficient. Is it necessary that the brain process should be set off by particular nerve impulses coming from the pain paths of the spinal cord or elsewhere? Well, ordinarily the brain does not excite or stimulate itself so as to produce the activities which correspond to pain; but in cases of tumour of the thalamus such self-excitation actually does occur. In these cases consciousness is frequently filled with the most terrific pains in the entire absence of any adequate causes in the portions of the body where the pains are localized. We are thus led to believe that the brain process is not only necessary but is sufficient for the arousal of the pain.

However, our inquiry is far from being finished. The brain is a large and complicated organ, through which nerve impulses run as through a maze. Moreover, the impulses do not stop in the brain, but pass out of it again on their way to the muscles and glands. We must follow the impulses further along their devious paths. The thalamus is a portion of the brain through which pass not only the pain nerves, but nearly all of the other sensory nerves of the body. The pain conductors have a definite center here, while the other nerves merely pass through the thalamus as a way station en route to the "cerebral cortex."

The Cerebral Cortex

The cerebral cortex is the largest and most complicated nerve junction area in the body. It is a sort of central switchboard for all of the sensory nerves and practically all of the motor nerves.

Within it all manner of interconnections can be established between these two systems of conductors. In order to appreciate the significance of the cerebral cortex it is necessary to understand that all nerve connections which are made through the brain or the spinal cord involve at least two separate nerve fibres. There is the incoming or sensory fibre and the outgoing or motor fibre. Between them is a contact device, which may be compared with an electric switch, which determines whether or not the impulse shall pass over from the sensory to the motor nerve. This "contact device" is apparently nothing more than a place of close proximity of the tips of the two fibres, but it is so important that it has been specially termed a "*synapse.*" There is little doubt that microscopic or chemical differences exist between synapses and other portions of a nerve fibre, these differences being responsible for the peculiar properties of the former.

It follows that the cerebral cortex is the most elaborate group of synapses in the whole nervous system. The general purpose of these synapses is to establish connections between sensory and motor fibres, but such connections are ordinarily made through a complicated series of synapses and fibres. Hence, if we trace the impulse from the pain nerves, after it has passed through the thalamus, we must be prepared to follow it through a number of synapses before it emerges from the cortex along a motor fibre. There can be no doubt that in nearly every instance the pain impulse does reach the cortex, since it is only by this route that it can influence "voluntary" behavior. However, there is a difference of opinion among authorities as to whether the presence of pain in consciousness requires cortical nerve activity. Henry Head, the eminent British neurologist, believes that the activity of the thalamus is sufficient. The present writer's view, on the other hand, is that pain — like the majority of sensations — does not arise until the nerve current reaches the cerebral cortex.

The Relation of Sensation to the Cortex

If we accept this latter view, we must go further and ask whether all of the cortex, or perhaps only a small portion of it, is involved. Does the sensation rest upon the activities of the fibres as wholes, or does it depend only upon the processes at the synapses? If the last alternative is adopted, is the complete series of cortical synapses concerned, or possibly only one member of the series? It is not possible to give an entirely convincing answer to these questions on the basis of proven facts. However, we can formulate an answer which is the simplest and most harmonious with the facts which are known. We shall not attempt at this time to give the answer in detail. Such detail will be reserved for a later chapter. Nevertheless, a general solution of the problem may be stated as follows.

The nerve fibres and synapses of the cortex can be divided into three broad groups. Firstly, there are the incoming fibres from the sensory side of the nervous system, together with the synapses which these fibres first form with other nerves in the cortex. Secondly, we must consider these latter nerves with their special synapses. Finally, there are the outgoing fibres, connecting through their own synapses with these same intermediate conductors. The cortex, in other words, has a *sensory*, an intermediate or *associative*, and a *motor* side. Now we have excellent experimental evidence that the motor-side activities in the cortex are *not* essential to the production of sensation, and cannot by themselves arouse sensation. There is also proof in certain cases that sensation — or a closely similar form of consciousness — can exist in the absence of the sensory-side activities. It would therefore appear that the *associative* fibres and synapses of the cortex are the ones which are essentially responsible for the presence of sensation in consciousness.

Ordinarily it is only possible to control the activities of the essential portions of the cortex by regulating the incoming sensory nerve impulses. However, the cortex apparently has a spontaneous activity of its own which underlies such conscious processes as imagination. Under abnormal conditions, as following the excessive use of alcohol, these automatic activities are greatly intensified, so that vivid hallucinations result. These are not distinguishable from true sensations except through their lack of correspondence with external reality. In certain cases of surgical operation upon the brain there have been opportunities for exciting the cerebral cortex directly by means of an electric current. In such cases the excitation was accompanied by sensation when the electrodes were applied to the sensory side of the cortex, but by movements only when it was applied to the motor side. These sensations were not localized in the brain, but in definite portions of the body outside of the brain. However, the exact localization in the body was determined by the position of the electrodes upon the cortical surface.

When the nerve currents or impulses leave the cortex on the motor side, they pass outwards along the so-called *motor* nerves and finally reach muscles or glands. Here they control the activities of the organs in question. Paralysis of the muscular system or any part of it is usually due to an interruption of the motor nerve impulses. In such paralysis important changes occur in the form of consciousness, but these changes are not referable directly to the cutting off of the motor nerve currents. They are due, rather, to the modified excitation of sensory nerves which start in the muscles or other portions of the motor apparatus. The facts indicate that if this secondary effect upon the sensory nerves did not exist, there would be no modification of consciousness resulting from cessation of the motor nerve impulses. It is for this reason that we are not inclined to regard any of these outgoing nervous activities as significant in the determination of sensation. Exactly similar considerations apply to the activities of the muscles and glands, themselves.

We may summarize our investigation thus far by saying that although the various internal sensations seem to depict directly the condition of portions of the body external to the nervous system, their direct determination actually lies within the cerebral cortex. Unless the bodily conditions result in nerve excitation and unless the corresponding impulse arrives at the cortex, there will be no sensation to correspond with the bodily condition in question. On the other hand, if the cortex spontaneously reproduces within itself the same activity which would normally follow from sensory causes, the sensation will be given in consciousness regardless of the absence of these causes. Accordingly, the relationship between the internal sensations and the physiological organism seems to reduce to a dependency of the sensations upon cortical processes. However, we must continue to bear in mind the impossibility of *identifying* the sensations with the cortical processes, since the latter are exclusively physical and hence concerned with electrons and protons, while the former are non-physical in nature. It is quite evident to anyone that the sensations are not *located* in the cortex.

The Relation of External Sensations to the Body

We must now consider the status of the *external sensations* in relation to organic activities. It is strange to find that an internal sensation like a stomach-ache depends upon something going on in the head. But it would be even stranger if we were to conclude that colors and noises have a similar determination. Such a conclusion would probably compel us to attribute external objects, as we see or hear them, to brain activities. Even experienced space and time would eventually succomb to the same sort of control. Nevertheless, we must consider the experimental facts which bear upon these questions.

If you are in a common-sense frame of mind, you do not have the slightest doubt that the book which you see before you is something which exists in its own right, and is directly perceived just as it exists. However, if you are reading at night and someone extinguishes the light, there is no longer any visible book in consciousness. Hence the existence of the book as a part of consciousness depends upon light, or radiant energy of certain wave-lengths. The simple experiment of closing your eyes will show why this is true, since here again the book disappears. The light must pass into the eye before the book can appear in consciousness. Within the eye there are many complex activities, and if any one of these is seriously disturbed, the book is modified or rendered non-existent as a conscious fact, a condition which we call "blindness." The final outcome of the processes occurring in the eye is the excitation of the fibres in the optic nerve, and it has been shown in hundreds of cases of blindness that in the absence of this excitation there can be no book in consciousness except in instances of hallucination.

The optic nerve currents pass inwards through a number of nerve "centers" or regions of synapses, and a large portion of the currents ultimately reach the cerebral cortex. Experience shows that if the impulses which are destined for the cortex are interrupted at any point before they reach their destination, blindness results and books are no longer visible. The same effect is noted when the sensory-side activities of the cortex itself are destroyed, as by disease of the areas to which the optic fibres pass. Limited injuries to the visual portion of the cortex produce corresponding "holes" in the seen world. Complete destruction of the visual areas of the cortex yields a type of blindness which impoverishes consciousness even more than does blindness due to interruption of the optic nerve currents.

It is found, however, that if the cortical damage is strictly limited to that portion of the cortex to which the optic nerve fibres are directly connected, it is still possible for the patient to imagine or to "think" in visual terms. But if some of the adjacent "association" areas of the cortical surface are also destroyed, the power of visual imagination is lost. These facts suggest that the "book" or other seen portion of consciousness probably depends directly upon the nerve activities which take place in the association regions and only indirectly upon those of the cortical sensory areas. In other words, as the nerve currents travel from the eyes to and through the brain, the book appears in consciousness only when the currents have arrived in the association zones. Concerning this proposition, there may be some doubt, but it is certain that the seen book cannot exist *before* the currents reach the cortex on the sensory side.

The nerve disturbances which originate in the eyes — like those emanating from the inner regions of the body — pass through the brain and emerge along motor nerves on their way to muscles and glands. We may therefore inquire whether these motor-side and out-going currents are essential to the production of the book in consciousness. The answer is similar to that given in the case of the internal sensations. There is no evidence that nerve processes on the out-going side have any influence directly upon consciousness. In general, it seems difficult to imagine the possible nature of such an influence. There is a definite correspondence, a similarity of structure, holding between the fact in consciousness and the nerve activities on the sensory side, but no fixed relationship can exist on the motor side because of the great diversity of muscular reactions which a single object may evoke. It is a fact of everyday experience that the manner in which we react to an object exerts relatively little influence upon its appearance, except in so far as our movements modify the relations of the object to our sense-organs.

External Sensations and the Cortex

Although we have shown that the activities of the cortex are *necessary* in order that books and other visible objects should exist in consciousness, we may still ask whether such cortical activities are *sufficient* for this purpose. Can we see a book without having a physical book actually before the eyes? Ordinarily, we cannot do this, because under these conditions the required cortical activities do not take place. However, there are states of brain disorder in which the necessary cortical processes seemingly occur in the absence of sensory causes. At any rate, in these states the patient sees objects clearly and definitely, and adjusts his movements to them, although physically no objects are present. We say that he is subject to an hallucination, because we believe ourselves to be in a normal state and we cannot see the same things which he sees. However, it is highly probable that the patient's cortical processes bear just as orderly a relation to his consciousness as do ours to our consciousness. In this case, it is sufficient for the appearance of any object in consciousness that its characteristic cortical accompaniment should be generated; the existence of sensory nerve currents and a "real" or physical object is not necessary.

It is important that we should realize fully what we have done when we have made the cortical process exclusively responsible for the existence of the object in consciousness. It is quite clear that the conscious object cannot be identified with the cortical activity because as we have seen before the two things are utterly different in kind. It is also impossible to think of the conscious objects as being *located* in the cortex. It is quite obvious to you, is it not, that the book which you see is not inside of your head? Even if it did seem to be inside of the head, there would still be the difficulty that the physical head — with its cerebral cortex — is not to be found in consciousness. The relationship between the object in consciousness and the cortical process is therefore of the sort which a logician might call purely "formal." Given the cortical activity, the object exists; otherwise not; but we have thus far suggested no means for explaining their interdependency. This is part of the mystery of mind which it is our purpose to set forth and, eventually if possible to solve.

A book, as it exists in consciousness, must be regarded as a combination of external sensations. Ordinarily, the most important of these sensations are visual and consist in a variety of colors, including variations of light and shade. However, if we are holding the book in the hand, touch and weight sensations are also involved, and these combine with the visual impressions in the formation of the total book. The book in consciousness is quite evidently not composed of particles of positive and negative electricity, after the formula of the theoretical physicist. There seems to be no legitimate way in which we can allege that the book in consciousness "really" has the nature assigned to a book by the physicist. If we say that the electrons and protons are "there" but do not "appear," this is only another way of denying that they are in consciousness. Hence "there" must be somewhere outside of consciousness. We do not need to deny the "reality" of the physical book, but we are compelled to locate it in another world than that of consciousness.

The sensations which unite to form a book are put together in a very special manner. They form a peculiar configuration or pattern in conscious *space:* the book shape. Moreover, this configuration — the book — is definitely localized in space: it is "before our eyes" at a certain distance. This distance consists of a fixed amount of space intervening between the eyes and the book. The book persists or remains in consciousness over a period of time, and if not rigidly held exhibits movements, as we turn the pages, etc. This persistence and motion of the book give it a structure in time in addition to the one which it possesses in space.

Now, when we affirm that the book in consciousness is determined by nerve activities occurring in the cerebral cortex, we assert in the first place that the sensations of which it is composed have a cortical basis. But we must go farther than this and attribute the space and time structure of the book to the cortical processes. The book as a whole, in all of its aspects, is a creature of the cortical activity. Disorders of the brain may modify the color or the weight of the book. They may also distort its form and motions. They can change its localization in space. Moreover, they are capable of distorting the space itself. The statements which apply to the book must evidently apply likewise to the entire "external world" of consciousness, of which the book is a part. No matter how "objective" this world may seem to be, its dependency upon the cortical nerve process remains the same as that of the most "internal" among the sensations.

Consciousness in General and the Cortex

When we have traced the relations existing between the physical organism and sensations — internal and external — together with their forms of combination, we have dealt with by far the greater part of consciousness. However, there are a few other constituents to be considered, such as thought, feeling and will. To these, we may add memory, imagination and attention, which are special phenomena of consciousness. All of these phenomena are characteristically "mental" in classification, and we might readily suppose that they lack a definite dependency upon physical processes, such as those of the nervous system. Numerous philosophers have from time to time advocated disbelief in a physical basis for such phenomena. The facts, however, are not favorable to this disbelief. They indicate that all parts and aspects of consciousness are alike determined by nerve processes in the cortex.

The exact manner in which thought, feeling, will, memory, imagination and attention are related to the physical nerve activities in the brain will be considered in later chapters. It will be recognized in general that these phenomena correspond to processes which are to a considerable degree independent of definite sense organs. They represent a more or less spontaneous activity in the cortex. The materials for this activity are usually provided by sensory processes; as feeling attaches to given sensations or objects, and memory faintly reproduces past impressions. We know, however, that any of the six phenomena which we have listed are possible in the absence of sensation. Observations upon brain disease show, on the other hand, that each of these phenomena can be independently affected or rendered impossible by special disorders in the cortex.

Thus far, we have been considering the relationship obtaining between special portions of consciousness and the physical world. We may summarize our conclusions by means of a few statements concerning the relationships of consciousness *as a whole.* As we have seen in our treatment of "the nature of consciousness," the internal sensations, the external sensations, and the so-called "subjective" parts of our awareness all combine to form a single coherent structure or system. Although the boundary between the internal and the external lies roughly in the body surface, as we experience it, the division is not altogether sharp; while feeling, memory, attention, and the like play over the entire conscious field. Consciousness is complex, yet at the same time integral or unified.

This unity of consciousness strongly suggests, if it does not prove, that the physiological activity which determines consciousness must also have a unitary character. If "thought" has a basis in the brain, it is likely that the external world of our experience will also have a similar, or at least a *contiguous* basis, because both are parts of one consciousness. Somewhere in the physical world, somewhere in the organism, somewhere in the nervous system, somewhere in the brain, there should be an integrated process which underlies consciousness in its entirety. This process, like consciousness, will be complex, although unified; and its various parts and aspects will be individually related to the parts and aspects of consciousness. We have decided, on the ground of known facts, that the physiological activity in question is to be found only in the association areas of the cerebral cortex.

CHAPTER VI

SENSATION AS THE FOUNDATION OF MIND

WE have seen in the preceding chapter that, although consciousness appears to depend exclusively upon activities taking place in the brain, the activities in question are themselves largely determined by forces acting through the sense-organs. Sensations, external as well as internal, are so called because of this dependency upon sense-organs. It is true that the cerebral cortex is capable of acting spontaneously, and that such activity is sufficient for the production of consciousness, but ordinarily there is comparatively little of this spontaneity. Moreover, the seeming spontaneity of the cortex and consciousness is almost wholly traceable to the persisting effects of past sensory influences. Imagination, for example, seems to represent a process due to the initiative of the brain alone, but its materials and oftimes its exact form, are derived from past experiences.

There has been a great deal of controversy among psychologists as to whether consciousness has any parts or powers whatsoever, which are not derived from sensation. The view that consciousness is wholly composed of sensations may be called *sensationalism.* According to this view, such mental phenomena as thought, feeling, will, memory, etc., are really sensory in character. They may consist in special kinds of sensations, or possibly only in special forms of combination of sensations which are otherwise known. Another doctrine which is similar to sensationalism is called *empiricism.* This latter doctrine states that whether or not consciousness is at present reducible to sensations, it is nevertheless entirely a *product* of sensation, *past* if not present. Those who have opposed these views have been known as rationalists or intuitionists, and they have been said to believe in the existence of *innate ideas*, or in some process other than sensation by which consciousness or brain activity is controlled.

Teachings of the rationalistic type are still to be found in some modern psychological circles. On the whole, however, modern psychology is committed to sensationalism, or at least to empiricism. The greater portion of consciousness is sensation, and what remains is something very similar to sensation and derived from it. This being the case it is important that we consider the nature and the physiological basis of sensation in some detail. We shall then have a firm foundation upon which to work out our conception of mind as a whole.

The Nature of Sensation

Psychologists frequently define sensations as *elements* of consciousness, without reference to the exact nature of the physiological processes with which these elements may be related. For example, red and pain are such elements, which can be recognized and named without any knowledge of the physiological conditions for their existence. The sensationalist regards consciousness as a mosaic which is built up exclusively of elements of this sort. However, a broader and more useful definition of sensation is one which introduces the physical factors in the situation. It says that sensation is that part or aspect of consciousness which depends in a fairly direct manner upon the excitation of sense-organs. The study of sensation is thus that of the relationship between consciousness and sense-organ activities. This study is not limited to a consideration of "elements," but may also be concerned with form and change. Thus, the red, white and blue in an American flag are sensory elements resting upon the manner in which the eyes are stimulated by light rays, but the *shape* of the flag is equally determined by the light rays, as are also the waving motions which the flag commonly exhibits.

A complete understanding of sensation demands a knowledge of what Sherrington, the famous British physiologist, calls "the afferent arc." "The afferent arc" is the forward or ingoing portion of the nerve conduction path which passes through the brain or other nerve centers, and which begins at the sense-organ. The outgoing portion, ending at a muscle is known as the "efferent arc." We shall consider the "efferent arc" in the next chapter, as a part of our discussion of behavior. The two arcs join at the nerve center, and together they form what may be called the total *response arc*. If we confine ourselves to pure physiology, we do not need to introduce the idea of consciousness into our study of the response arc. As psychologists, however, we are forced to consider the interrelations of the two. (See Fig. 7.)

One of the most complete and best understood departments of sensation is that of vision. A somewhat detailed presentation of the mechanism of visual sensation will serve as an example of the nature and problems of sensation in general.

What Happens in "Seeing"

A thorough understanding of what happens when we see an object demands that we start with the physical object, itself, rather than beginning at the eye. The physical object, it will be borne in mind, is quite a different thing from the object which is in consciousness. Let us consider the case of a cubical block of wood, such as a child might use as a plaything. Suppose that it is painted with the yellow pigment known as lead chromate. The block as a physical entity consists mainly of a chemical substance called cellulose. This material is arranged into cells and fibres corresponding with the biological structure of the plant from which the wood was originally taken. The cellulose, itself, has a structure in terms of atoms of carbon, hydrogen and oxygen; these being put together into a complex pattern to form each of the billions of cellulose molecules which compose the wood. Carbon, hydrogen and oxygen, however, are nothing but aggregations of electrons and protons in three typical forms of combination. The body of the physical block therefore reduces to a very complex structure of the fundamental electrical units.

The pigment which covers the block to a thickness of perhaps a thousandth of an inch is similar to the block itself in general character, except that its protons and electrons are put together in a somewhat different form. The pigment proper is made up of lead and chromium atoms in addition to those of oxygen. If the pigment is incorporated into a "paint," carbon and hydrogen atoms of the linseed oil or other menstruum will also be present. The paint layer is perhaps ten million molecules thick. Still, the entire object is just so many electrons and protons arranged in space in a peculiar way. The pigment is not "really" yellow; it only "looks" yellow. Why it "looks" so is a problem in visual sensation, which we must now consider.

In order that there should be vision, it is not sufficient that a physical object should exist before the eyes. There must also be a source of so-called "light." We say "so-called" because "light" is more a psychological than a physical term. The thing corresponding to light in the physical world is known as *radiant energy*, of a certain limited kind. Radiant energy is a disturbance of the fields of force which surround electrons and protons, and representing the attractions or repulsions which these particles have for one another. The disturbance takes the form of a *wave* moving from one such particle to others, along the intervening "lines of force." Physicists used to believe in the existence of a fluid called the æther in which such waves were produced and travelled, but now — under the influence of the Einstein theory — they are content to consider the waves merely as moving disturbances of the electrical forces between the particles.

Let us suppose that in our case the waves are due to the vibration of the electrons in the surface of the hot filament within an electric incandescent lamp. The wave disturbance travels very rapidly away from the filament and some of the waves strike the block of wood. Here they penetrate the pigment surface to a depth of perhaps a thousand molecules and set some of the electrons within these molecules into vibratory motion. In generating this motion the waves themselves are extinguished, because their energy passes over to the electrons. However, the oscillations of the pigment electrons generate new waves, which spread out from the pigment surface in all directions. Now the original waves from the lamp filament were of a large number of different *lengths;* but among the new waves sent out by the pigment, there will be conspicuously few of the *shorter* length waves. We say that the pigment *absorbs* these shorter waves and *reflects* the longer ones. This is part of the reason why the pigment "looks" yellow whereas the "light" which it received from the lamp is approximately "white."

At the instant when the wave disturbances first leave the pigment electrons, the physical block assumes a condition which it may maintain throughout the act of vision; but there is still no vision. The object in consciousness has still to come into existence. Before this can appear the waves must pass through the intervening space to the eye of the observer. They must traverse the transparent substance of the eye and be bent — or "refracted" — by interaction with the molecules of this substance, so as to form an image or light-picture of the object upon the retina. The retina corresponds to the sensitive film in a photographic camera. The "retinal image" of the object which is thus produced is made up wholly of electrical wave-disturbances which are similar in general character to those which were sent off from the pigment surface. The image has no color and it is neither light nor dark. It is simply a pattern of electro-magnetic waves which vary in intensity or energy and possibly in average (wave-) length from one point to another.

The retinal image although a purely physical activity differs from the object itself in not containing any molecules, electrons or protons. It also differs in shape and completeness; it is not a cube but only a projection of a cube, representing the surfaces of the object which face the eyes. If no surface of the cube happens to be exactly perpendicular to the line connecting its central point with a point mid-way between the observer's eyes, all of the surfaces as represented in the image will be foreshortened. The sides of the cube away from the eyes have no representation. In addition to these imperfections, there are other distortions which are due to the so-called optical aberrations of the eyes. It may also be noted that in case the object is fairly close the images in the right and left eyes, respectively, will not be identical in shape. They will be two different "perspectives" of the object from two separated points of view.

The fact that these images of the cube have been formed on the retinas does not complete the act of vision. The observer, as yet, sees nothing; there is no object as yet in consciousness. In order that this should come into being the energy which is carried in the images must excite or "stimulate" the retinas. This process is believed to consist in the decomposition of a chemical substance which exists inside of the retinal "rods and cones." These rods and cones are minute "receptor" mechanisms which are connected to the individual fibres of the optic nerves. They are present in great profusion in all parts of the retina, except that the rods are absent in a small area which corresponds to the region of most distinct vision; and here the cones are packed very closely together. It has been shown that the rods are the organs of night vision, while the cones are responsible for day vision and the discrimination of colors (differences in wave-length) to which the rods are not specifically sensitive. (See Fig. 4.)

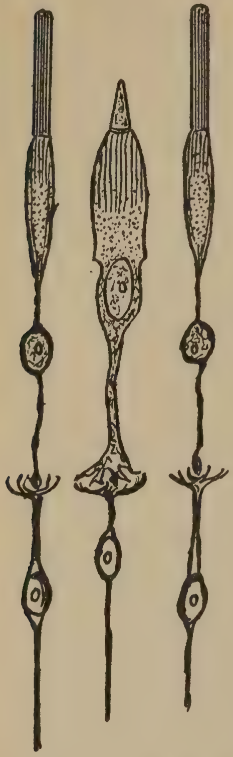

FIG. 4. RECEPTORS AND THEIR NERVE CONNECTIONS.

Retinal rods and cones and the "bi-polar" cells to which they transmit their nerve currents.

The chemical process in the retinal "receptors" follows the outline laid down by the image. Where the latter is of high energy, the chemical reaction will be of high intensity; where the image has low energy the reaction will be correspondingly low. However, the chemical effect will not necessarily be strictly *proportional* to the image energy; it may follow a law of "diminishing returns" as the energy increases. Moreover, it is a well demonstrated fact that the rods and cones vary in their general sensitiveness with changing light conditions. This process of adaptation, as it is called, tends to compensate for low or high illumination, so as always to provide an adequate but never an excessive chemical effect over a very wide range of energy values. Another way in which the receptor process fails to copy the retinal image values appears in the fact that waves of different length have quite different powers of setting off the chemical decomposition. In fact, there is a vast scale of wave-lengths which have no exciting effect at all upon the retina, regardless of their energy. These include the "ultra-violet" and "infra-red" rays, "heat rays," "radio waves," "X-rays," and the "gamma rays" from radioactive substances.

Thus we see that although the retinal image determines the form of the retinal excitation, it does so through a complex set of relationships, which necessitate that the excitation itself should be as different from the image as the image is from the object. The retinal excitation undoubtedly *represents* the original cubical block, but it *resembles* the latter only slightly. And still there is no vision.

The influence now passes on from the retinal receptors to the optic nerve fibres. Here a further change takes place in the representation. It becomes even less perfect and complete than it is in the retinal image. There are, of course, two optic nerves — one for each eye — and each nerve contains about half a million individual conducting fibres. However, this is far too few to provide a separate conductor for each of the rods or cones, since there are many millions of these in each retina. It is only for the central portion of each retina — where cones alone exist and are packed closely together to provide the most distinct vision — that "private lines" of connection are provided. In other parts of the retina the connection is made on the "party line" principle, a considerable number of receiving organs being joined to a single optic nerve fibre. This obviously means that there must be a sort of *condensation* of the representation as it passes over to the optic nerves.

The Visual Nerve Activity

We shall not discuss here in detail the physical nature of the nerve current, although this is quite well understood and is of fundamental importance in solving the "mystery of mind." Because of the great importance of this topic we shall reserve a whole chapter for its consideration, below. It is sufficient now to regard the nerve current as an electrical disturbance which travels along the individual nerve fibres like sound in a speaking tube or even water in a pipe. There must be some aspect of the nerve current which is variable in degree, so that we can speak of the strength or intensity of the current in each fibre. It is also apparently necessary that in some fibres the current should be capable of varying in *kind* or in quality.

The exact intensity and quality of the currents in individual nerve fibres must be determined by what exists at *corresponding* points of the retinal image or of the object. Nevertheless, the quite different nature of the nerve process will mean that the properties of such corresponding points cannot be the *same* in the nerve as in the image or object. The factor which stands for energy of electron vibration in the object will be some other species of physical activity in the nerve. Wave-length in the radiant energy emitted by the object will be represented by something different in the nerve process, or at any rate the wave-lengths will not be the same in the two cases.

The optic nerve currents which are set up by the reaction of the retinal receptors to the image of the yellow cube must have a peculiar form or pattern which is determined by the cube. The pattern or distribution of the currents over the cross-section of the nerve would be different if the object were a ball instead of a block. However, the pattern itself cannot be cubical in the case of the block and could not be spherical in the case of the ball. In other words, for each specific object there is a definite nerve current formation, but this formation never *duplicates* the object. The importance of this principle, as we shall see, is that consciousness can get its clue concerning the nature of the object only from the character of the nerve current pattern; and this latter is merely a kind of symbol of the original reality which stands before the eyes.

As the currents flow along the optic nerves from the eyes towards the brain their pattern formation changes under the control of the fibres along which the currents pass. One of the most important changes occurs at the *optic chiasma*, which is the junction point of the two optic nerves. Here the currents from the two eyes are brought together and are then rearranged in a very surprising manner. The fibres coming from the right hand sides of both retinas are grouped together and pass into the right hand side of the brain. In a similar way, those connecting with the left hand sides of both retinas go to the left hand side of the brain. Some fibres from the centers of both retinas find their way to both sides of the brain. In any one of these groups the fibres from similarly situated retinal points run in close proximity, but their currents do not actually combine to form a single current in spite of this proximity. After the currents leave the chiasma they travel in the so-called optic tracts, which are nerve fibre cables embedded in the substance of the brain. (See Fig. 5.)

The peculiar rearrangement of the nerve currents which occurs at the chiasma means that the representation of the cube is divided into halves at this point. The left hand portion of the cube is represented by the nerve currents in the right-hand optic tract, while the right hand portion is represented in the left-hand optic tract. The reason for this reversal of side between object and brain lies in the fact that the rays cross from one side to the other when they enter the eyes. The representation in each optic tract is duplex, although one-sided, since there are currents from corresponding points of both eyes. In the case of a small area of the cube, at which we are directly looking, a complete representation is present in both optic tracts. It is evident that the resemblance of the nerve current pattern to the original cube has been still further reduced. *And even now there is no object in consciousness.*

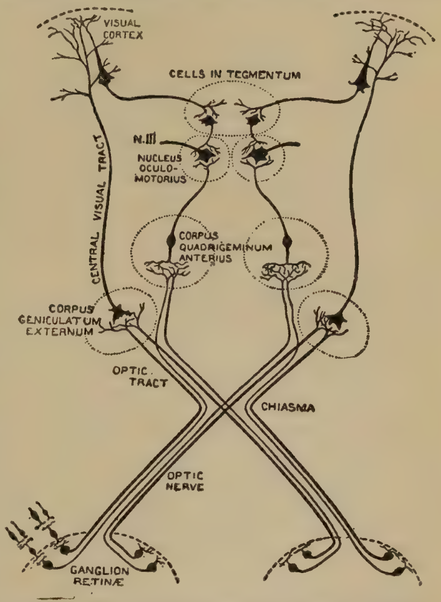

FIG. 5. THE PATH OF THE VISUAL NERVE CURRENTS. (This figure is reproduced from Quain's Elements of Anatomy, Vol. 3, Part I, 1908, p. 240.)

The nerve currents start in the two retinas, shown at the bottom of the figure and pass to the brain along a system of parallel paths, as shown.

As the currents pass on along the optic tracts they are again divided on each side into two groups, making four groups in all. This subdivision probably involves currents representing all of the different portions of the object rather evenly, so that the representations on each side of the brain are now roughly in duplicate. However, the split is *not* such as to separate the right and left eye currents from one another again. One of the new lines of conduction on either side passes to a relatively internal brain center, while the other ends in a more external center. We say "ends" because at these "centers" the conducting fibres which start in the retinas come to a termination anatomically. However, the currents are passed on to new fibres which begin in the centers in question and connect with other centers further along.

The currents which pass through the "internal" centers can apparently be neglected so far as consciousness or the psychological act of seeing is concerned. They serve as a basis for unconscious or automatic regulations of the eye, such as the contraction of the pupil, and winking when an object approaches the eye. However, the currents which take the path through the "external" center go directly to the cerebral cortex, and are responsible for the brain activities which underlie consciousness. The "cortex," as the derivation of the name indicates, is a skin-like coating of that portion of the brain known as the cerebrum, so that connecting with the cortex means connecting with an area or *surface.* The nerve fibres, with their currents, approach the cortex much as the radii of a sphere are related to its surface, or the supporting members of an umbrella frame work to the top cover. Accordingly, this portion of the nerve path is known as the *optic radiation.*

Vision and the Cortex

To aid imagination, the form of the cerebrum may be compared to that of the kernel of a walnut (although it may be doubted whether an accurate knowledge of anatomy lies at the basis of current colloquialisms). The two halves of the kernel, placed vertically, represent the two cerebral "hemispheres," while the surface irregularities may be compared with the convolutions and fissures of the cerebrum. The visual currents are conducted to a portion of the cerebral cortex which corresponds to surfaces of the walnut kernel facing one another along the central plane of cleavage between the two halves. The currents from the right-hand optic tract naturally go to the right hemisphere, while those from the left-hand track pass to the left hemisphere. The small central regions of the two retinas are represented upon both hemispheres.

In spite of the wide difference in form and contour which exists between the retinal surfaces and those of the cerebral hemispheres, the correspondence between the two is quite definitely determined. Each point in the retina connects with a specific point in the cortex. If a small portion of the cortical surface is destroyed, blindness is produced over a correspondingly small portion of the field of vision. There have been many opportunities to study this local blindness in cases of injury to the brain due to wounds received in battle; and such studies have shown exactly how the retinas are connected to the cortex. These observations leave no doubt that when the eyes are looking at such an object as a yellow cubical block, there is a perfectly definite pattern of nerve currents arriving at the cortical surface. However, this pattern has practically no resemblance to the original object. (See Frontispiece)

The question now arises as to whether the nerve conduction has gone far enough to generate an object in consciousness. When the currents first arrive at the cortex, the brain has received the information which it needs to complete the act of vision. The majority of psychologists seem to believe that the conscious object arises at this moment. However, there is plenty of evidence that mere reception of the currents at the cortex is not sufficient to make the perceived object complete. In order to introduce those features of the object which are due to its *familiarity*, the currents must spread over the cortical surface, and be influenced by the physical records in the cortex which correspond to *memory*. Psychological analysis shows very clearly that objects as they are presented in consciousness are affected to a very great degree by such memory records. Hence the present writer is of the opinion that the conscious object does not arise immediately the nerve currents strike the cortex, but only after they have spread over its surface perhaps a considerable distance. In this spreading, the form of the nerve activity probably diverges even more than previously from the form of the actual object before the eyes.

Whatever may be the exact phase of the cortical conduction which gives rise to the object in consciousness, it is certain that the nerve currents do not have to pass *beyond* the cortex in order that this should occur. The object snaps into being as the currents traverse either the sensory or the association regions of the cerebrum. *But the object, itself, is not in the cerebrum.* It is in *consciousness*, and consciousness is not in the cerebrum. The relation between the conscious object and the nerve current pattern in the cortex creates a profound mystery. There can be no doubt that one determines the other, but *how* we shall not attempt to say, here. Later on we shall offer an astounding explanation.

We ordinarily think about the object in consciousness as if it could be identified with the physical object which is before the eyes. It should already be quite clear to the reader that such an identification is utterly impossible. The two objects are vastly more different than black and white. Black and white, and colors in general, are properties of objects in consciousness, but physical objects must be conceived wholly in electrical terms. Nevertheless, there is a *relation* of a fairly definite kind between the psychological and the physical objects. Given a physical block before the eyes, we ordinarily have a block in consciousness, if the various conduction processes which we have just described function properly. In a state of hallucination or illusion the block exists in consciousness without these processes, and in blindness the physical object is present in the absence of the "conscious" one but commonly their relationship is quite reliable.

Sensation vs. *Perception*

Now, the problems of *sensation* and *perception* in psychology, as the writer sees them, are mainly concerned with a study of this relationship. They are not confined, of course, to the visual example which we have been considering. We could trace out a similar scheme of things for hearing, for touch, for taste, for smell, or for any other set of nerves which carry currents to the brain. In each case there is first some physical object or condition which arouses or stimulates a sense organ. This is followed by excitation of the attached nerve fibres and the resulting nerve currents follow a devious course along these fibres until they finally reach the cerebral cortex. Only after the currents have arrived at the cortex does the corresponding sensation or object appear in consciousness. The problem of sensation is not so much that of the kind of phenomenon which arises in consciousness, as it is that of the manner in which this phenomenon is determined by the response of the sense-organ. It is clear that this determination is *indirect*, since it occurs only through the medium of a tortuous channel of nerve conduction.

In order to draw a clear line of demarcation between sensation and perception, we may say that perception is concerned with the relationship which exists between the *physical object* and the object in consciousness; while sensation concerns the manner in which the object in consciousness is determined by the *stimulus*, the *sense-organ activity*, and the beginning of the nerve conduction. The object in consciousness purports to represent the physical object, and in so far as it succeeds in doing so it is a *perception*. On the other hand, in so far as it represents the peculiarities of the sense-organ, and its affiliated processes, the object in consciousness is to be regarded as *sensation*.

The situation which we have to consider here may be compared to that which exists in the organization of a daily newspaper. The physical objects or conditions correspond to the world of things, men, and events which the newspaper attempts to describe. The sense-organs resemble the reportorial staff of the newspaper, the means by which the reporters gather the news being the stimuli. The agencies through which the reporters communicate the news to the office of the paper may be compared with the conducting nerve fibres. These agencies include the mail, the telegraph, the telephone, etc. At the office of the paper there are editors who select and modify the "copy" which is sent in by the reporters. They also make contributions of their own. These editors may be likened to the cortical conditions underlying memory, interest, attention, etc., which play an important part in determining the exact form of the final cortical activity which directly corresponds to consciousness. This final activity may be compared with the electrotype from which the paper is printed, and consciousness corresponds with the paper itself.

In terms of this analogy, perception is the truth about the world's events in so far as the paper actually succeeds in telling it. Sensation is that part of the telling which is determined by the peculiarities of the reporters and the means by which they work. For example, the same event can obviously be described in many different languages or, in the same language, by a wide variety of words. Different reporters will perceive and emphasize different aspects of the event, and this will depend upon the particular sources of information which they have, as well as upon their own powers of observation or interests. In a similar manner, the nerve currents which reach the cortex from different sense-organs which are in contact with the same object represent different aspects of the object, and the representation differs in its medium. Vision records the optical characteristic of the object in terms of light and color, while hearing is a response to acoustic properties in terms of noise or musical tone. However, in so far as the various representations are "true" they are consistent with one another and can be combined into a single true *perception.*

The Problem of Visual Perception

As a concrete example of these principles, we may consider some of the problems which arise in connection with "seeing an object." The first question which we may ask is as to whether we *see* the object in consciousness or the physical object. It is certain that the former is the only one with which we have direct acquaintance, since it is quite clear that the latter is not in consciousness. However, there seems to be little significance in saying that we "see" the object in consciousness, since this adds very little to the more general statement that the object in question is a part of consciousness. We may therefore state simply that we *have* this object, or that it is *present.* The predicate of "being seen" seems therefore to be reserved for the physical object which is in front of the physical eyes. To be seen consequently means: to send off radiant energy, which enters an observer's eyes, stimulates his retinas, arouses optic nerve currents, which are transmitted to the cerebral cortex, whereupon a visual object appears in consciousness.

The problem of the relation of the visual object to the thing seen is that of visual *perception.* The first kind of relationship which we are tempted to consider is that of *similarity.* To what degree does the object in consciousness resemble the physical object? Only in so far as such similarity exists, can vision be said to provide us with real information or "knowledge" of the seen object. However, it is evident from our previous discussion that the similarity is comparatively slight. In the first place, any similarity which exists is evidently restricted to *structure* and excludes *substance*. The substance of our physical cube or block is negative and positive electricity, while that of the cube in consciousness is color (including light and shade as well as yellow). These two substances seem to be utterly different in kind.

The *structure* of the two objects, however, apparently offers certain points of similarity. The object in consciousness is evidently one kind of a cube, since we are able to call it by that name. The physical object is also defined as a cube. Nevertheless, it is readily proven that the two cubes are of different kinds. Even if we forget all about Einstein and his peculiar conception of physical space, it is evident that the visual cube is a cube-from-a-certain-point-of-view, while the physical cube is independent of any particular point of view. Although the visual cube "looks" cubical, it has front and rear faces which differ radically from each other in that the former are vividly present while the latter are only faintly delineated, if at all. There is nothing about a physical cube to distinguish its front and rear faces in this way. The fact that there is an observer somewhere in its vicinity does not alter the cube, or spoil its perfect symmetry.

Another radical difference between the structures of the two cubes lies in the fact that the physical cube is made up of a vast number of very tiny particles which are separated by relatively enormous empty spaces, whereas the visual cube is not broken up and is uniform in substance. The particles are in violent motion, but no such motion appears in the object which is in consciousness. In general, all of the properties of the physical object which the physicist has been compelled to "discover" are evidently not manifest in the everyday visual representation. If they were thus manifest, they would not need to be "discovered."

Nevertheless, if the physicist actually has discovered these properties, and knows what he is talking about, he must somehow have developed a representation of the object which is more faithful than is the everyday visual representatoin. He has done this by considering what is common to many separate views or "sights" of the same kind of physical thing. Not only this, he has brought together the deliverances of all of the senses, and has elaborated his sensory relations with the object by means of instruments such as the microscope and the chemical balance. Logic and imagination have played their part, too. The result is a synthesis and refinement in the form of the physical idea of the object, which is as truthful a representation as we have yet been able to develop.

Just this same kind of a process takes place in what the psychologist knows as *perception*, in general. The visual object in our consciousness is not the product simply of the nerve currents which are flowing into the cortex along the optic tracts at the given moment. The form of our consciousness is influenced to a much greater extent that we would readily believe, by *past* currents which have flowed in along these same channels. But not merely along the visual channels. If we are touching, or ever have touched the object in question, the nerve currents or records from the touch sense combine with those of vision. And so with all other kinds of sensation which relate to the given object. All combine into a synthetic whole which is presumably more accurately representative of the real nature of the physical thing than are the deliverances of any single sense, taken alone.

Thus, the outside world influences the brain through a great multiplicity of separate nerve channels. These separate inflowing currents are reassembled in the cortex and underlie as good a conscious representation of the original facts as the total information will permit.

The Problems of Visual Sensation

If we undertake to analyze out the separate contributions of the individual sense channels, we embark upon the study of *sensation*. The problems of sensation in the case of vision are concerned primarily with color (including light and shade) and the determination of the form of the visual object by that of the retinal images. We find in the typical human consciousness, six distinct primary colors: black, white, red, yellow, green and blue. All other colors can be regarded as compounds of selected groups of these primaries. Investigation shows that physical objects have no properties which correspond accurately to the different colors. The radiant energy which is emitted or reflected from such objects is characterized by wave-length and intensity, and if the conditions of the eye, the optic nerves, etc. are held constant, these properties of the radiant energy determine the color of the object in consciousness. However, under many practical as well as experimental conditions, colors show a very variable relationship to wave-length and intensity; so that we are led to believe that they depend more fundamentally upon the chemical processes which take place in the retinas than they do upon the nature of the physical object or of radiant energy. The working out of the vastly complicated system of relationships between colors (as parts of the conscious object) and what happens in the eye constitutes the fascinating problem of *color sensation.* (See Fig. 6.)

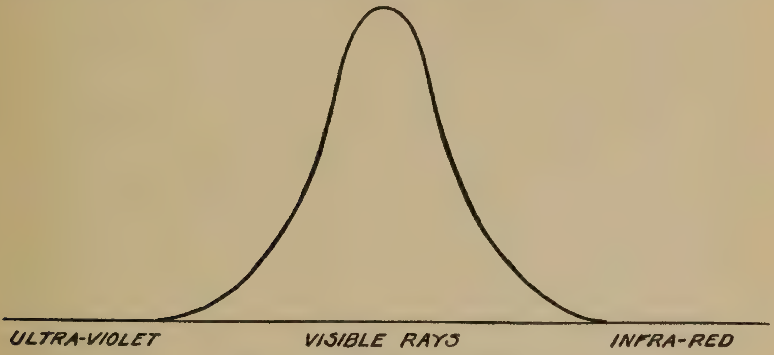

FIG. 6. THE "VISIBILITY CURVE."

This curve shows how the response of the eye varies with the wave-length of light, when the physical energy or intensity of the rays remains unchanged.

The problem of *visual form sensation* is often included by psychologists in the discussion of perception. This may be in part, because it involves a combination and synthesis of the nerve currents received from the two eyes. The basis for this synthesis appears to lie in the fact, which we have already noted, that the nerve currents from similar points on the two retinas are carried to closely adjacent points on the cerebral hemispheres. However, the relationship obtaining between the shape of the visual object in consciousness and that of the image upon a single retina is of even more fundamental importance. We have suggested some of the problems involved in this relationship, as we endeavored above to trace the conduction of the nerve currents which were set off by the yellow block placed before the eyes.

It is not within the scope of the present book to enter into any of these specific problems of sensation or perception in detail. Our purpose in this chapter has been to employ the visual instance as an illustrative example of what the psychologist is working on under the captions in question. It is hoped that the reader will appreciate from the above discussion what an enormously complicated field of research is here open to investigation. Although vision is perhaps the most complex of the senses, the other departments of sensation present very intricate and definite situations for our consideration. Vision has been studied more than any other sense, but is so far from being thoroughly understood that our knowledge of it can be regarded as being in a medieval condition. For the non-psychological layman, there is no mystery in sensation, because he is not aware of the existence of the relationships which we have been endeavoring to describe. The more we delve into these relationships, however, the more full of mystery they become.

The mystery of mind begins with the mystery of sensation. The nerve currents which are poured into the cortex by the sense organs are the formative agencies for all consciousness. They furnish the cortex with its driving energy and with its only fundamental guiding influence. Therefore it is correct to regard sensation, as we have defined it, as the foundation of mind. We may now proceed to consider some of the things which are built upon this foundation.

CHAPTER VII

BEHAVIOR AS THE EXPRESSION OF MIND

AMERICAN psychologists have recently been much excited by a movement in their science known as *behaviorism*. According to the exponents of this doctrine, the true function of psychology is to study the *behavior* of men and animals. The problem is that of exactly what men and animals *do* under varying conditions, rather than that of what they sense, perceive, feel or think. Behaviorists vary in the degree of violence with which they attack the more conventional forms of psychology. John Watson, the leader of the movement, says that he does not know what consciousness is, and he therefore denies that psychology has any concern with such topics as feeling and thought. Other less radical behaviorists admit the existence of consciousness, but claim that it cannot profitably be studied by scientific methods. A very considerable number of American psychologists are behaviorists to some degree, in that they tend to deprecate the study of consciousness and to emphasize that of behavior.

The importance to psychology of the study of behavior can hardly be overestimated. However, a denial of the importance of an understanding of consciousness seems to be quite absurd. The only statement which can be more absurd is a denial of its existence. If there is no consciousness there can be no experience, no knowledge, no science; hence no behaviorism. As for the importance of consciousness, how can unconscious beings or processes be subject to such a qualification as importance? The question of importance only arises because of the bearing of facts or ideas upon consciousness. Hence it would seem that consciousness itself is the most important of all things. Next in importance is an understanding of the relations between consciousness and the rest of the universe. This constitutes the "mystery of mind," which it is the true function of psychology to solve.

How are Bodily Movements Controlled?

In the preceding chapter we have sketched the relationship which obtains between consciousness and the first half of the nerve conduction path. It is now our privilege to consider its relation to the last half of the same path. Consciousness seems to be controlled directly by what happens at the point of junction of these two halves of the path; but it naturally has an indirect relationship to processes taking place throughout the nerve path. For the forward half this relationship involves us in the study of sensation and perception. For the rearward half, it leads us to consider *volition* and *action.*

Now, this so-called rearward half transmits the nerve currents from the cerebral cortex to the voluntary muscles of the body. The movements of these muscles are controlled entirely by the nature of the nerve currents in question. Indeed, even the quiet postures of the body are due to the inflow of accurately determined nerve impulses. Whatever a man is "doing" therefore depends upon the character of the excitation which the outgoing nerves receive at the cortex. There are, of course, certain simple kinds of behavior which are controlled by nerve centers other than the cortex. Breathing, the movements of the stomach, the contraction of the pupil, and similar "reflexes" are governed by nerve currents which pass through junction points in the lower brain regions, the spinal cord, or even the solar plexus. But, however important these automatic movements may be to the physiologist or behaviorist, they are of minor interest to the psychologist just because of their relative independence of the cortex and their consequent lack of correspondence with consciousness.

We ordinarily think of the movements of our body as being *caused* by certain processes which go on in our consciousness. We believe that the muscles are obedient to a mental operation called "will." If we are Christian Scientists, we go even farther and hold that a sufficiently powerful will can control any bodily condition whatsoever. Now the psychologist is naturally concerned to find out what "will" is and how it works. The task has proven difficult, or at any rate the conclusions which have been reached are considerably at variance with the common-sense view of the situation.

Let us first consider the problem of bodily movement from the purely physiological side; that is, without any reference to consciousness. In other words, for the time being let us become behaviorists.

The Nature of "Response"

When a man acts, he ordinarily does so because of some stimulus which is influencing or has influenced his sense-organs. He *responds* to some definite object or condition in his environment. Thus, when he sits down, he does so because he sees a chair. He may also do so because he sees food on the table in front of the chair, or because he has heard someone say that dinner is ready. In any case, certain sensory stimuli have set off his action. Very frequently, the stimulus is due to a condition of the body itself, as would be the case if the man sat down at the the dinner table because he was

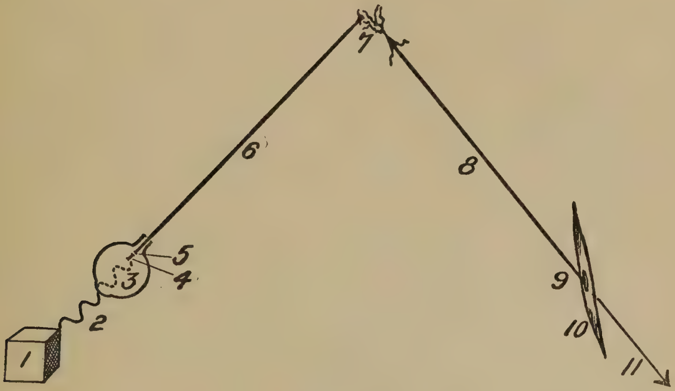

FIG. 7. DIAGRAM OF VISUAL RESPONSE.

Showing symbolically the sequence of events when we react to things seen. 1 is the object, which reflects light, 2 (the stimulus to vision). 3 is the "sense organ process," refraction of light in the eye; while 4 is the "receptor process," the photochemical response of the retinal rods or cones. 5 is the stimulation of the ingoing nerve, and 6 is the conduction along this nerve. At 7 the central or "synaptic process" occurs, this being followed by the outward conduction, 8, which acts upon the muscle at 9. 10 is the contraction or relaxation of the muscle and 11 is the effect produced upon other portions of the body or its environment.

hungry. Hunger is a sensation derived from stimulation of the sense-cells in the wall of the stomach.

The total process or series of events by which an object sets off a muscular movement may be called *response.* This process can be regarded as a continuous chain of influences which flows through nerve channels from stimulus (sense-organ) to muscle. In our discussion of sensation we have indicated its details from object to cortex. The fact that consciousness arises or is modified as the influence strikes the cortex does not affect the fact that the process is routed through the cortex for the outward path to the muscles. The pure physiologist and behaviorist is ignorant of the existence of consciousness and its association with the currents which are passing through the brain. Thus, the cortex is only a way station, the real terminus being the voluntary muscles. *Response* includes this whole activity, but excludes (without denying the existence of) consciousness. (See Fig. 7.)

The most interesting general feature of response is the manner in which it connects definite movements or postures with specific objects (conditions or situations). Thus, we respond to chairs by sitting in them, rather than by trying to lie down on them, this reaction being reserved for a bed or a couch. We *turn* knobs on doors but *push down* or *lift* latches. We eat apples, but not round stones of equal size. This *specificity* of response, as we may call it, does not appear to follow any natural mechanical law. Thus, the movements involved in sitting down in a chair cannot be deduced from the shape of the chair-image which is cast upon the retina. It would be even more difficult to deduce them from the condition of the stomach wall which brings forth the sensation of hunger. It is evident, however, that the connection of movement with stimulus is ordinarily such as to favor the continued existence of the individual or the species. This is not always true, of course, since some persons intentionally and others accidentally make movements which lead to their deaths.

The Cortex as a Switchboard

In order to account for the specificity of response — the tendency towards a fixed connection of movement with stimulus — we must regard the cerebral cortex as a kind of central switchboard through which arbitrary connections are made. Definite kinds and patterns of nerve currents arrive at the cortex from the sense-organs. These may be compared to telephone subscribers who are making calls, or to their communication with the central operator. Equally definite nerve currents leave the cortex for the muscles, and these may be regarded as analogous to calls made by the operator. At the cortex, as at the central telephone exchange, incoming and outgoing messages are directed along lines which are wholly due to the particular central connections which are established. The question as to *how* such connections are made is a very important one and will be discussed in detail in a subsequent chapter. (See Fig. 8.)

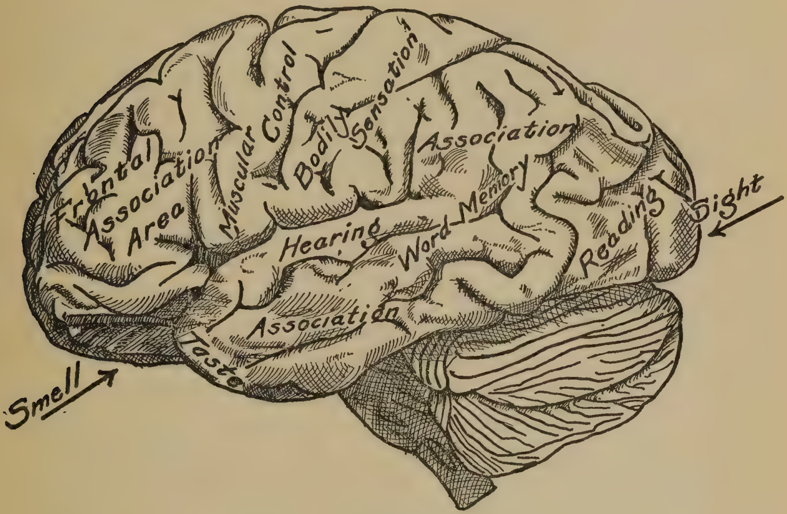

FIG. 8. SENSORY, MOTOR AND ASSOCIATION AREAS OF THE CEREBRAL CORTEX.

The figure shows the brain as it appears, undissected, when viewed from the left-hand side. (Adapted from Ladd and Woodworth)

When we think of connections between sense-organs and muscles being made in the cortex according to the analogy of a telephone switchboard, we are of course indulging in over-simplification. It cannot be doubted that such connections are actually made, but the process is not merely that of linking a particular set of incoming fibres with an exclusive group of outgoing fibres. This must be true, because a chair and a tree both excite many fibres of the optic nerve in common. Indeed, we always see a chair or a tree in a larger environment; and this total situation acts upon *all* of the optic fibres. Thus, practically any visual reaction rests upon the simultaneous activity of the entire visual system. However, these activities differ in kind, in degree, and in form. It is these latter three characteristics of the nerve process, therefore, which must determine the outgoing currents from the cortex. Certain movements must be connected not with particular sensory fibres, but with certain *kinds, degrees and forms* of incoming nerve currents.

Entirely similar statements apply to the outgoing currents. Almost all muscular reactions involve a very large number of muscles simultaneously, or in an orderly succession. In a sense, the complete musculature of the body is concerned even in the smallest local movement, since such movements usually cannot be successfully executed unless the body is held in a definite posture. For example, as I write upon the typewriter at the present moment, the work is done mainly by movements of the fingers, but would be impossible if the arms and body as a whole did not remain accurately placed before the machine. Accordingly, we must say that the nerve currents which leave the cortex to set off different movements, are differentiated in kind, degree and form, rather than in the mere identity of the nerve fibres along which they pass.

Excitation "Patterns"

In order to permit a condensed statement of the principles thus involved, let us employ the word *pattern* to stand for the combinaton of "kind, degree and form." A "pattern" is a definite arrangement of elements which may differ quantitatively or qualitatively or in both ways. Thus, an American flag is a pattern in which different points vary in color (quality) and in brightness (quantity). The group of nerve currents which are generated in the eye and transmitted to the cerebral cortex in the act of looking at the flag, constitute another pattern. When we take off our hats to the flag, still a further pattern is concerned, the pattern in which our muscles are excited. This muscle movement pattern is determined by the pattern of the nerve currents which leave the cortex. (See Frontispiece)

We may speak of the pattern of incoming currents at the cortex as *sensory*, while that of the outgoing currents may be called *motor*. In these terms, the connections which are established at the cortical switchboard are not mere linkages of individual conducting fibres, but are *associations of sensory and motor patterns*. If the pattern which comes in along the optic nerve represents a chair, the pattern which goes out along the motor nerves represents sitting down. It is evident that the mechanism in the cortex which links patterns in this way must be a very complicated and ingenious one.

The Relation of Behavior to Consciousness

The above suggested explanation of how bodily movements are controlled is apparently quite different from the common-sense explanation. The latter view introduces consciousness into the process. It states that after the nerve currents have reached the brain so that we perceive an object or situation, we *decide* to act in a certain way, whereupon the appropriate muscular movement follows. Perception and decision are mental events which are supposed to be inserted between the incoming and outgoing cortical currents.

The majority of modern psychologists reject this common-sense explanation as being no explanation at all since it introduces more mysteries than it solves. It is much easier to understand how one set of nerve currents can act upon another than to comprehend the manner in which they might influence consciousness or in which consciousness might control the nerve currents. Nevertheless, no one can deny rightfully the fact that perceptions and decisions actually exist. No one can deny, moreover, that they are definitely related or correlated with what happens in the nervous system. Certain perceptions accompany certain incoming currents, and certain decisions accompany certain outgoing currents. The only question at issue, therefore, is as to whether nerve currents can *cause* events in consciousness and *vice versa*. Some philosophers have thought that this action can work one way but not the other. There seem to be more scientific reasons for believing that the brain processes regulate consciousness than that consciousness can regulate the brain processes. This is because there is apparently no basis for consciousness except in the brain activity; whereas outgoing nerve currents find an entirely adequate basis in the incoming currents as they are modified in passing through the cortical switchboard.

Important as this problem is for a complete understanding of mind, we shall not attempt to solve it at present. It will be considered again in a later chapter. For the time being we shall confine ourselves to known facts and adopt a point of view which is not very far removed from that of common-sense. According to this view behavior can be regarded as an *expression of consciousness*, even if the behavior is not actually controlled by consciousness through a strict law of cause and effect. Voluntary action *follows* the dictates of consciousness, whether or not it is *dragged* by them. We may admit that nerve conduction through the brain takes a path which is determined entirely in a physical way, without conscious interference or assistance. Nevertheless, such of these nerve currents as pass through the cortex are in perfect harmony with the then existing demands of consciousness.

Just as the study of sensation (and perception) involves the relation between the first half of the nerve path and consciousness; so the science of *behavior* is concerned with the relation which holds between the last half of the same path and conscious events. It is to be admitted that this conception of behavior differs from that of most behaviorists, who tend to eliminate consciousness altogether. However, it enables us to attach to the word behavior a significance which is greater than that of mere mechanical movement of the body. It concerns also the manner in which these movements are related to our perceptions, feelings, memories, desires, etc.

Having established these preliminary principles, we may proceed to consider some of the actual relations which exist between consciousness and movement. Some of the older psychologists regarded consciousness in a manner which made it seem to be a sort of spiritual entity divorced from the practical affairs of life. Therefore it came as quite a revelation when William James and some of his followers developed the so-called "motor theory of consciousness," in which they insisted that consciousness tends constantly to express itself in movements, and finds its meaning in such activity. This "motor theory" has evolved into the *functional psychology* of the present day. The functional psychologist is interested primarily in the bearing of different kinds and forms of consciousness upon bodily movement, and he believes that every feature of consciousness has a relationship to some specific kind of behavior.

We can appreciate that the "motor theory" is a very reasonable doctrine when we realize that cerebral activity (with which consciousness is directly associated) is part of a mechanism whose sole function is the control of muscular movement. Of what use are sense-organs if they do not enable us to adjust our movements more accurately to our environment than we could without them? The same query applies to the inward conducting nerve fibres, and to all of the central nervous transfer regions, such as the spinal cord and the brain. Consciousness should act, in many respects, *as if* it were one of the links in this mechanism. This is because it is determined in a definite way by the cortical process, which actually *is* such a link.

Perception and Behavior

When we view consciousness from the point of view of behavior we find that even such a thing as perception has "motor significance." The objects which we perceive correspond to objects to which we can definitely and specifically react. Our ability to move in a definite and characteristic manner with respect to them is largely concerned in defining or delimiting the objects themselves. Thus, a chair and a bed are regarded as *two* objects and are perceived as such because they demand different muscular reactions. Physically, they might be considered as forming a single more complex object. Similarly, situations and relationships which we perceive in a clean-cut fashion always have some definite movement demands. A nail sticking into an automobile tire may be taken as an example. This does not differ greatly in physical form from a twig growing out of the round limb of a tree, but we do not "especially notice" the twig because it does not demand any special practical reaction.

What we have previously called "objects in consciousness" may be regarded as psychological units with respect to which our behavior is governed. At any moment our behavior is centered about some particular object or group of objects. Thus, if we are driving an automobile our movements are regulated with respect to successive objects which may obstruct our path. If the car stalls, our reactions concentrate upon the motor and move from one object to another under the hood until we find the cause of the trouble. At each moment the center of our consciousness contains a representation of the object in question.

Imagination and Association

Sometimes the object with respect to which our movements are being adjusted is not actually being presented to our senses. This is the case, for example, when one is waiting at a railway station for a train to come in. The train, or someone upon it, is the central physical object. Our coming to the station, as well as our waiting there, is a response to this object. Now, although the physical object is absent, the object-in-consciousness is usually present in such cases. As we stand waiting for the train, our consciousness is not ordinarily entirely devoid of a "train representation." A faint reproduction or *image* of the train is commonly present. We may therefore state that whenever there is a motor reaction, there tends to be either a vivid or a faint representation in consciousness of the object with respect to which we are reacting. The faint representation, or image, is to be attributed to a cortical activity which is not directly due to incoming sensory nerve currents, although it is usually based upon a record or impression made by such currents in the past. This cortical record or memory process actually controls the outgoing nerve currents of the moment, and physically determines our behavior.

Such reproductive cortical activities are ordinarily aroused in accordance with the principle known as *association*. Although the activities, themselves, are not due to present sensory nerve currents, they are aroused by other activities which do have an immediate sensory foundation. Thus, we drove to the station because we received a telephone call from a friend saying that he would arrive on a certain train. The telephone conversation provided us with concrete sensory stimuli which evoked auditory sensations and perceptions in consciousness. These were followed, through association, by images of the railway station, the road to the station, the train and the friend's face. The words which we heard during the conversation were able to arouse these particular images because *at some time in the past these same words had formed parts of a single consciousness which also contained the said images or the vivid perceptions corresponding to the latter.* The principle of association is evidently a very important factor in determining the nature of our behavior. We shall have more to say concerning it in subsequent chapters.

Attention and Action

We have said above that "the center of our consciousness" tends to contain a representation of the object about which our muscular movements turn. This implies that consciousness has a form something like that of a circle, with a center and a periphery. It also implies that the object which dominates our behavior is not the only one to be represented in consciousness. The problems which are thus suggested are the ones which psychologists consider under the heading of *attention.* Saying that an object occupies the center of consciousness is the same as stating that it is the thing to which we are *attending.* Furthermore, the corresponding physical object is the one with respect to which we are adjusting our movements. Attention is the process in consciousness which corresponds to picking the object of our reactions on the physiological side.

The objects which lie in the periphery of consciousness, and which are not "being attended to," may be regarded as *candidates* for attention. In a sense, they are being *partially* attended to, since they are superior in position to objects which are not in consciousness at all. The psychologist says that the objects in the center or focus, are characterized by a high degree of *clearness*, while those in the periphery are less clear. There may be quite a number of degrees of clearness, so that objects can be arranged in a series in accordance with their respective clearness degrees. Objects outside of consciousness might also be arranged in order of the likelihood of their getting into consciousness. These two series represent all of the candidates for attention in order of their chances of being elected.

Attention stands for something more than the mere shifting of stimuli over the sense-organs. Attention passes from one sense to another, and from sense to imagination, often regardless of sensory events which are occurring simultaneously. Thus, I now attend to my typewriter keyboard, now to the rattle of a window near me, and again to the word-images which foreshadow what I am going to write. In each case, however, attention is a forerunner and index of action. If the rattle of the window dominates my consciousness, I am almost sure to get up from my chair and try to eliminate the noise. If the word-images keep control, I continue to write. From time to time, a cigarette box at my side fluctuates in the periphery of my visual field, and if it gains the center, I reach for a cigarette. The factors which control the entrance and exit of such occupants of the conscious focus are of the utmost interest and will be considered in detail later on in this book.

The point which we wish to emphasize here is that the form and operation of the attention are expressed physically in the individual's behavior. We can predict sensation and perception (to a less degree) by considering the forces which are acting upon the sense-organs; but to ascertain the nature and object of attentive processes we must study what the man is doing.

The Nature of "Will"

The theory of attention is intimately bound up with the modern psychological account of will or volition. Although all kinds of consciousness are implicated in action, nevertheless there are some features which are more closely linked with it than are others. From one point of view, we are acting all of the time, except possibly when we are in a deep sleep. However, some of our moments of action are more violent and more important than others. To sit in a Morris chair and think is to act; but when our thoughts lead to some conclusion which "causes" us to leap from the chair and rush to the telephone, the action is more vigorous and critical. At any rate, we can say that there was a sudden *change* in the mode of our behavior. Psychologists have attempted to determine exactly what happens in consciousness when such sudden changes occur.

The popular and also the classical notion is that each voluntary act is preceded by a sort of fiat of will. An unprejudiced examination of consciousness fails, however, to reveal this distinctive will process. In a vast number of cases we act, so to speak, automatically as soon as the appropriate object or "idea" (image) appears in consciousness. When the given form of behavior is not quite so automatic, and is more or less in the stage of being learned, the action may be definitely preceded by the "idea" of the action. In other words, we form an image in consciousness of our body going through the specified movement, or assuming the required posture. The precondition for the carrying out of the behavior is simply that this image should dominate consciousness or be "attended to." Thus, while writing, I hesitate concerning the spelling of a word; an image of the dictionary on the table beside me appears in my consciousness; this is followed by an image of my right arm and hand reaching for the book; this image enters the focus of consciousness and immediately: I find myself reaching and grasping the dictionary. This is the most that modern psychology has been able to find concerning the intimate preconditions of action in consciousness.

It is to be noted that whenever we move in a definite manner, or even maintain a fixed posture, the muscular reactions excite special sense-organs which are embedded in the muscles, joints and tendons. The excitation in question follows a pattern which is characteristic of the given reaction, and the consequent inward-flowing nerve currents carry this pattern to the cerebral cortex. The result in consciousness is a sensation or perception of our own specific movements or postures. Such sensations are among the most important of the "internal" group, as we have already noticed. Therefore, each reaction is reported back to the cortex, so to speak. The brain records of these "motor sensations" are naturally *associated* permanently with the records of accompanying external sensations, so that the image of the dictionary can immediately bring into mind the image of the act of reaching for the dictionary. On the purely physiological side, the "reporting" nerve currents from the motor apparatus play a very important rôle in the smooth control of complicated movements by the cortex or other brain centers (such as the cerebellum).[1]

Thought and Action

The process which we call *will*, in everyday life, usually has to do with an elaborate series of *thoughts* which precede and accompany certain lines of action. Thought is ordinarily a sequence of images which successively occupy the center of consciousness. Such images are faint reproductions of objects or situations. They may be constructed of materials drawn from any one of the senses. Some of us think mainly in visual images, others in images of things heard, and others mainly in images of themselves acting. One of the most common types of thinking is the verbal type, in which the material consists of faintly spoken or heard words.

The order which the images follow during our thinking is determined in part by the principle of association, which reproduces the combinations and sequences which we have known in the past. However there is also a creative activity, in which the past associations are broken down and the elements are put together into new combinations. This is what we call imagination, or constructive thinking. Thought may also be either logical or illogical. It is logical if it follows certain rules which tell how thinking must be conducted if it is always to lead to true conclusions. The greatest thinkers are those who combine imagination with logic.

The counterpart of thought in the brain is probably to be found in some circuitous and lengthy route which the nerve currents pursue in endeavoring to pass through the cortex and reach the muscles. The cortex is a tremendous maze of nerve paths in which currents can conceivably spiral around for a long time before they finally emerge. When thinking intervenes, the response to sensory stimulation is delayed. According to this view, even thought — the mental phenomenon *par excellence* — is an accessory to action. At any rate, this is true of the cerebral accompaniments of thought.

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[1] Another important contribution to such reporting currents is made from the special equilibrium sense organs contained in the inner ear. These are concerned with the state of movements of the head, which frequently represent those of the body as a whole.

"Effort"

When our thinking pursues a fixed goal, and expresses itself in action consistent with the attainment of this goal, we are said to manifest *will.* In consciousness, this kind of thinking is frequently subject to distraction. Images lurk in the margin which are at variance with the fixed goal. It takes "will" in this sense to write a book. When the would-be author sits down before his typewriter his attention is commonly besieged by images which point to quite different lines of action. If the distracting images are kept in the margin of consciousness, the "will" is strong. If they enter the focus and tempt the writer away from his task, the "will" is weak. In either case, but more particularly in the former, there is a *struggle* in consciousness. While this contest of images goes on, there is general failure of action. The cortex, so to speak, cannot decide along what path to discharge its currents. The result is that it discharges at least a portion of them diffusely, into all of the muscles of the body. This produces a general state of tension, which is represented in consciousness by a corresponding bodily sensation. The "feeling of effort" which we are said to have during such an experience is identified by modern psychologists with this sensation. It is a symptom rather than a controlling agency.

Conclusion

In this chapter we have not attempted to say what determines our thought and action along one line in preference to another. This will be the problem of the next chapter. For the present we may consider that we have established the following propositions. The function or biological purpose of the nervous system is the control of the muscles of the body. This control must be regulated by two considerations, the needs of the organism and the nature of its environment. The sense-organs place the nervous system in contact with the environment and together with the latter determine the kind of nerve currents which are transmitted to the brain. These ingoing currents are always destined in general for the muscles,

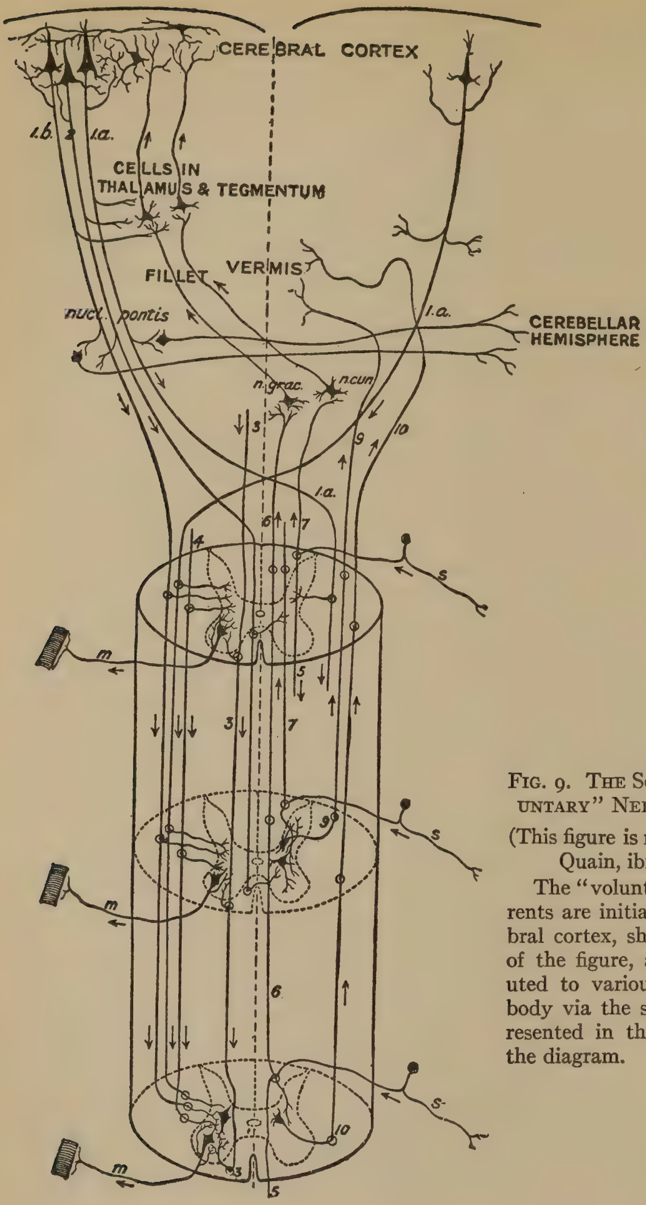

Fig. 9. The Source of "Voluntary" Nerve Currents.

(This figure is reproduced from Quain, ibid., p. 93.)

The "voluntary" nerve currents are initiated in the cerebral cortex, shown at the top of the figure, and are distributed to various parts of the body via the spinal cord, represented in the lower half of the diagram.

but the particular manner in which they are passed on to the muscles depends upon the connections which are operative in the cerebral cortex. They traverse the complicated paths of the cortex as if the latter were a central switchboard. Then they leave along the outgoing nerve channels and energize the muscular system in a definite way. Thus the environment governs the man's behavior through the medium of his sense-organs, his brain, and other portions of the nerve circuit. (See Fig. 9.)

Consciousness does not interfere with or intervene in this process. The process is entirely physical in nature. It could be described wholly in terms of ultimate electrons and protons. Nevertheless, consciousness exists, and follows in its form and activity the pattern set by the nerve currents in the cortex. Consciousness, so to speak, is modelled after the cortical process. Consequently, it is modelled along lines which relate it to behavior. We can study the relations which exist between consciousness and muscular movement, just as we do those between consciousness and the excitation of sense-organs. In the former study we learn the motor significance of such psychological phenomena as perception, memory, imagination, association, attention, volition, and thought. Just as consciousness *seems* to be the product of sensation, so it *seems* to produce our behavior. We have good reason, however, for asserting that the incoming nerve currents are not the real causes of consciousness and that our behavior is not causally dependent upon it. These are paradoxes which form portions of "the mystery of mind."

CHAPTER VIII

WHY PEOPLE BEHAVE AS THEY DO

To explain the habits and other behavior tendencies of men and animals is one of the most urgent tasks which face the psychologist. The layman is probably more interested in this branch of psychology than in any other. Unfortunately, however, scientific progress on this problem has been rather slow. Nevertheless, we may hope that by pursuing some lines of thought which have been started in preceding chapters, we may throw considerable light upon it.

We have represented the nervous system as a conducting path which connects the sense-organs with the muscles, via certain nerve centers of which the cerebral cortex is the most important. The nature of the nerve currents which reach the cortex is controlled by the objects in front of the sense-organs; while that of the currents which leave the cortex depends upon the cortex itself. A definite kind of *response* — a habit, an instinct, or any type of behavior — consists of a particular connecting together of incoming and outgoing currents. This connection lies in the cortex; it is here that the particular knot is tied between stimulus and reaction, which determines the given specific response. What is the nature of this knot and what is the process by which it is tied?

The Properties of Nerve Currents

In attempting to answer these questions, let us think of each different kind of incoming current as having a private nerve path. Let us treat the outgoing currents in the same manner. We have already admitted that this is an unduly simplified way of looking at the process, since many nerve paths are used in common by a wide variety of different currents, whether incoming or outgoing. Nevertheless, the simplification can be justified for purposes of exposition. On the basis of this assumption, our problem can be reduced to the following terms. How are incoming and outgoing nerves connected?

What is the nature of such connections, and how are they established?

A general answer to the first part of the question can be deduced from a study of the properties of conducting systems, of which the nervous system is merely a special case. Among other conducting systems we may mention the net-works of water pipes or of electrical wires which are to be found in any modern building. Any such system possesses three fundamental characteristics, when in operation. One is the volume or *quantity* of the *current* which flows through it at any point. This can be measured in gallons per minute in the case of water, or in amperes (coulombs per second) in the case of an electrical conductor. The second characteristic is the *pressure* which causes the current to flow. In the hydraulic instance, this may be measured in pounds per square inch; in the electrical case in volts. The final characteristic is the *resistance* which the pipes or the wires offer to the current. There is no well-known measure of this for water systems, but for electrical circuits it is measured in "ohms."

Nerve currents, as we shall see, are undeniably different from currents of water or electricity, but their flow can nevertheless be conceived as characterized by the factors of current strength, pressure, and resistance. Now there is a general principle, known in electrical science as Ohm's law, which associates these three factors, for any conducting system. This principle states that the current strength is proportional to the pressure and inversely proportional to the resistance. The higher the pressure, the more current; the higher the resistance, the less current. Although this law is almost self-evident, it is of the greatest importance in understanding the behavior of conducting systems. We should therefore attempt to apply it to the nervous system.

In order to make such an application it is necessary to understand more exactly the nature of current strength, pressure and resistance as they exist in nerve conduction. The most important of these, for our present purposes, is the resistance factor. In a later chapter, where we shall discuss the physical nature of the nervous activity in detail, we shall analyze the current and pressure factors in a more thorough manner than is at present necessary. In regard to the current, we may now note the following facts. Nerve activity is discontinuous or pulsatory in character. The current flow is not a smooth transfer, as in the case of water moving in a pipe, but occurs as a succession of jerks, such as are transmitted along a rope attached to a boat which is being pulled ashore by hand. Under ordinary conditions these jerks are all of the same strength, regardless of the magnitude of the force which starts them. This uniformity of the nerve pulses is represented by the so-called "all or none" principle, which we shall discuss later. It follows from this principle that variations in the strength of the nerve current must consist of changes in the *number of pulses* which pass along the nerve in a given time. If only one fibre is considered, this will be a matter of the closeness of packing of the pulses, one behind another. If, however, more than one fibre is considered, we shall be compelled to count the number of fibres which are acting in conjunction.

When we seek the analogue of pressure in nerve conduction, we think first of the stimulus. Thus, in vision, we may conceive the "light" which "strikes" the retina of the eye as furnishing the "push" which sends the currents along the optic nerve. In the case of sound the vibrations of the air may be thought of as furnishing the required pressure. This idea is valid for the first step in the process, in which the sense-organ receiver is set into action; but modern investigations indicate that nerve fibres, when once they are set going, generate their own pressure. Some fibres are naturally high pressure fibres, while others are characterized by low pressure. However, nerve fibres are not "self-starters"; they require a push to get them going. This is supplied, as we have seen, by the stimulus. Hence, we must say that both the outside force and the inside force of the nerve itself combine to determine the pressure factor. We may consider the internal force as being represented by the magnitude of the individual nerve pulses, while the external factor corresponds with the number of these pulses which are started.

Synaptic Resistance

The nature of resistance in nerve paths may be compared with that in a system of large water pipes containing a great many valves or cocks for controlling the flow of the water. There is resistance to the flow of the water throughout every inch of the pipe system; but by far the greatest resistance is encountered at the valves. In case the valve is closed this resistance is so great that no water at all can pass. If the valve does not leak the resistance is "infinite" and the current is "shut off." When the valve is partially open the resistance decreases as the degree of openness increases. Because of Ohm's law, or its equivalent, the water current increases as the resistance is decreased and in this way the flow can be regulated to any desired strength, by adjusting the valve. Where there are a number of valves, the direction of flow and the destination of the current can obviously be controlled by choosing and correctly adjusting the proper valves.

Now, the nervous system seems to be constructed on this same general plan. The nerve fibres must have resistance all along their lengths. Otherwise, the current would be infinite in its intensity. However, this fibre resistance seems to be practically constant and uniform. The resistance which *counts* is located at restricted points analogous to the valves in the water system. These nerve valves are located where one nerve fibre makes contact with another, and is in a position to pass on its impulses to the latter. Such contact points — as we have seen — are called *synapses*, a name which it will be worth while for the reader to learn. (See Fig. 10.) It is quite likely that the contact point — or possibly we ought to call it the separation point — of the nerve fibres is all that is required to produce the valve action. At any rate, we name the resistance after the place where it occurs, and characterize it as *synaptic resistance.*

There are several important considerations regarding synaptic resistance which we should bear carefully in mind. The first is that apparently it is only by means of the regulation of this resistance that the nervous system can control its own currents. The resistance of the fibres, as contrasted with the synapses, is constant. The pressure contribution which is made by the fibres is substantially constant. Only the synaptic resistance is variable. The stimulus, or the external environment can determine the currents, at least in part, through its contribution to the pressure factor. It pushes at certain sensory points in certain definite degrees and ways, and thus initiates a determined nerve current pattern. However, the manner in which this current is passed on from the incoming to the outgoing nerves at the cerebral cortex will depend upon the synaptic resistance which exists between the two sets of nerves at this point.

Now we know that the cerebral cortex is a region of multitudinous synapses. The cortex is that part of the brain which is popularly referred to as "gray matter." Of course, there is gray matter in other portions of the nervous system, too, but wherever it is found it indicates the presence of synapses. "White matter," on the other hand, consists of straight conducting fibres, with no variable resistance points. The number of synapses in the cortex runs into many billions. In fact, the synapses are so numerous that we feel justified in believing that there is one between each sensory (incoming) and every motor (outgoing) fibre. In other words, each incoming fibre is connected with each outgoing fibre, so that every incoming fibre enters into as many synapses as there are outgoing fibres.

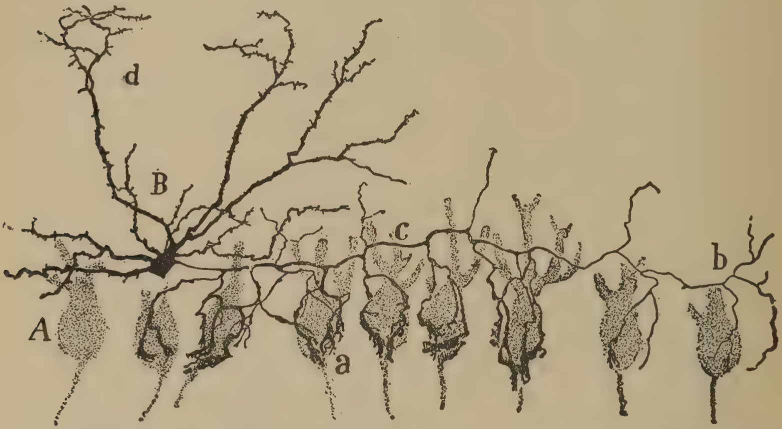

FIG. 10. A SYSTEM OF SYNAPSES. (This figure is reproduced from Quain, ibid., p. 23.)

This figure shows a group of synapses formed between a single nerve cell, B, and six other cells. This enables the nerve currents in B to be passed on to all of the other cells, thus spreading the excitation.

This may not be possible anatomically without the interposition of intermediate fibres, but there are a vast number of these in the cortex. The cerebrum as a whole is a network of such intermediate fibres, through which nerve currents are passed on from the sensory to the motor side.

The Distribution of Cortical Resistances

If we suppose that the cortex possesses a network structure of this sort, the question arises as to why a sensory current coming in along a single fibre does not set off all of the motor fibres, regardless of its nature or identity. The answer is that the resistance of nearly all of the synapses which are formed with a single incoming fibre must be very high. Possibly only one of them will have a sufficiently low resistance to allow a current to pass. The result would therefore be the same as if this low resistance synapse were the only one which existed. However, there is an obvious advantage of this arrangement over one in which the incoming fibre has an exclusive connection to a certain outgoing fibre. This advantage is evidently that by a change in the relative resistances of the synapses a radical change in the connections can be established. In other words, the system is rendered flexible or adaptable.

If we accept this conception of the mechanism in the cortex, we must decide that the distribution of cortical synaptic resistance is the all-important factor in determining the individual's response to his environment. If the resistance is high at all of the synapses which are made by an incoming nerve fibre there will be no outgoing current at all. The current will be blocked at the cortex. If the resistance is low at some particular synaptic point, the current will pass at this point into a particular outgoing channel which will determine the nature of the muscular reaction. The current takes the line of "least resistance." It is probable that when the resistance exceeds a certain limiting value, no current at all will get through. This is due to the "all or none" tendency of nerve, which we have already mentioned.

We may therefore compare the nervous system to a system of water pipes which act somewhat as follows. A million supply lines reach a certain control station, and a million feed lines leave this station. Each supply line has a pipe connection with a shut-off to each and every feed line. As a rule, only one of the shut-offs which is attached to a single supply pipe is open at one time. However, there is an engineer, or else an automatic regulating device at the station who or which is capable of closing certain shut-offs and opening others. The supply lines evidently correspond to the sensory nerves, while the feed lines are to be compared with the motor nerves. The station with its valves corresponds with the cortex. In such a water system the supply lines would ordinarily be filled with water at all times; but in the case of the nervous system the current exists only when the sense-organ is excited. The condition of the valves at the central station — whether open or closed — only determines how the water *will* flow if any actually comes in along a given supply pipe. If we start water along any such supply pipe, it will emerge from a particular feed pipe the identity of which must be determined by the manner in which the valves are set at the central station.

The question which now arises is as to who or what adjusts the cortical shut-offs. The classical and popular view suggests that we try to answer the question "who"? However, our expressed determination to work out the problem along purely physical lines precludes such an answer on our part. There is no "engineer" in the cortex, or making his influence felt there. The question therefore resolves itself into that of discovering a mechanism which shall be capable of adjusting the resistances of cortical synapses.

Non-cortical "Reflexes"

However, before we embark upon a detailed study of this problem, we should acknowledge certain important facts. These facts show that there are many forms of specific response which do not depend upon the cortex and its patterns of synaptic resistance. This is possible because the cortex is not the only central station which the nervous system contains. It is merely the largest and most important of such stations. Without worrying the reader with a long list of long names of subordinate nerve transfer stations, we may nevertheless recognize the kind of reactions which are set off through such centers. They are ordinarily of the type known as "simple reflexes." Examples are coughing, sneezing, winking, the movements of the intestines, etc., etc.

Now, a study of such simple reflexes leaves little doubt that they depend upon fixed, inborn nerve connections. They follow almost inevitably as a consequence of certain forms of sensory excitation. Irritation of the membrane of the larynx or trachea, for example, inevitably evokes a cough, when the intensity of the disturbance becomes sufficiently great. If we ask why these nerve connections exist, we shall be compelled to say, simply, that the individual was born "that way." There must be something in the constitution of the human germ cell which lays down the nerve fibres in definite conjunctions in the lower nerve centers. All of the simple reflexes are common to all normal human beings, and have obvious utility in maintaining life. For these reasons we ordinarily have little interest in their origin. Such interest is mainly concentrated upon the types of behavior in which men are very likely to differ. These types do not have a rigid basis in heredity, and are for the most part dependent upon the cortex rather than upon the lower nerve junction points.

How is Cortical Resistance Regulated?

If the cortex is the organ of learned responses, we must suppose that the paths of the nerve currents which pass through it are not determined by heredity but by "experience." This means that at birth — or at least prior to the beginning of sensory impression — all of the cortical synapses have practically the same resistance. We may suppose that this resistance is quite high. If there are a million outlets for each inflowing nerve current, they are all initially of substantially equal high resistance. The process of learning, of forming a habit, must consist in lowering the resistance of one (or a few) of the alternative outlets, so that it becomes the actually operative one. Another possible mode of learning would be to raise the resistance of all of the synapses except one (or a few), but this is evidently a much more complicated method.

We return, therefore, to our problem of how the resistance of the cortical synapses is regulated — by "experience."

"Trial and Error"

Apparently the first requisite, if we are to learn to do anything, is that we should "try something." A careful study of actual learning in men and animals indicates that the fundamental process is one of "trial and error." For example, a dog in trying for the first time to escape from a cage, makes a large number of different random movements until he finally hits upon one which lifts the latch and lets him out. If he is imprisoned in the cage a second time, he may perform the correct reaction at once. Many forms of human learning which may seem on the surface to depend upon imitation or the following of instructions, actually rest upon trial and error. The majority of human habits are acquired by an obvious trial and error procedure.

Two main questions arise out of this situation. The first is: "What is the source of the trials?" The second is: "What distinguishes between those trials which are 'errors' and those which are successes?" In each case, we wish to know what happens to the resistance of the synapses in the cortex.

Now, if all of the cortical synapses were of *exactly* equal high resistance, no effective nerve currents could ever get started through any of them. However, we may feel quite sure on general principles that the equality is not absolute. Let us suppose, that nature, so to speak, actually desired to make the equality absolute. She would not succeed, because no two things can ever be made exactly alike. It would be even more difficult to *keep* them alike, if they could be made so in the beginning. This is especially true of delicate, semi-liquid, structures such as the nerve synapses. The similarity between the resistances of the cortical synapses, although a marked characteristic in the beginning, is nevertheless only approximate.

It follows, therefore, that if a high pressure nerve current reaches the cortex and insists upon going through to the motor side, it will find one synapse very slightly more conductive than all of the others. This condition will be entirely accidental, and might shift to another synapse within a short time as a result of random physiological fluctuations occurring in the cortex. The slightly superior conducting power of the given synapse is not systematically determined by heredity and does not represent any uniformity among different individuals. If the resulting reaction has any utility, this will be an entirely accidental feature. Nevertheless, the nerve current takes the line of least resistance, no matter how slight the inferiority. The all or none principle of nerve action makes it legitimate for us to suppose that the slightest difference in resistance will suffice to send all of the current along a single channel and none of it along any of the others.

In addition to this principle of slight accidental inequality among cortical synapses, the writer believes that there is a definite mechanism for producing "trials." This mechanism must be conceived to operate in a manner similar to mechanical gambling devices. It slightly opens and closes the synapses in a fluctuating and random manner. It tries out a wide variety of connections betweeen sensory and motor fibres. The practical value of such a piece of apparatus in the cortex is evident. When the individual is placed in an environment for which he has no prepared reactions, it is important that he be able to experiment with different ways of meeting the situation. He must be capable of making some kind of definite response, and if this fails, of trying something else. The essential difference between connections produced in this way and those due directly to heredity is that the former have no reliable survival value, while the latter have been tested by centuries of evolution.

The Principle of Selection

In the absence of a slight, random fluctuation in the resistance of the cortical synapses, such as we have just assumed, it would seem impossible for the cortex to develop any new paths of conduction. It would be impossible for the individual to *try* anything and hence to *learn* anything. However, the mere spinning of a cortical roulette wheel will not of itself produce any reliable and permanently useful forms of response. In addition to the chance, "trial," connections there must be some fixed method of selecting out of such trials the ones which are useful and of rejecting those which are useless or detrimental. In others words, there must by some physiological criterion of success and failure.

Such a criterion is to be looked for among the *consequences* of the given trial response. These consequences must be in the nature of effects produced upon the individual organism. The effects must involve the excitation of the nervous system in a certain way: so that a success will tend to stamp in the line of conduction which caused the success. On the other hand, a positive failure — resulting in injury to the organism — should operate upon the nervous system so as to obliterate the path of conduction which caused the failure. It is quite evident that the portion of the nervous system which must be thus affected is none other than the cerebral cortex, for it is here that the determining connections are established.

In order to visualize the nature of this process, let us consider two time-honored examples. A baby is placed in front of a candle. The rays from the candle reach its eyes, stimulate its retina, and send a characteristic nerve current up its optic nerve to the cerebral cortex. The baby may do almost any conceivable thing as a reaction to this stimulus. But suppose that, finally, it thrusts its hand into the flame. This is a response to the candle which has important biological significance. It is a radical failure, since the flame begins to burn into the child's flesh and destroy it. What is the result? The child not only immediately withdraws the hand, but it will probably never again thrust its finger into a candle flame. It has learned not to put its finger into flames, or has learned to "fear fire." How was this done? We say that the child's subsequent behavior is due to the fact that it "got hurt," but this does not explain what happened in the nervous system. (See Fig. 11.)

The second time-honored example has to do with the same child when first confronted by a piece of candy. Accidentally the candy is grasped and carried to the mouth. It is kept there, and the next time a similar object is presented the child immediately puts the object in its mouth. The child has learned to eat candy, or to provide its system with an essential food substance (sugar). If the object had been a stone in the first instance, instead of a piece of candy, this habit would not have been formed. What is the explanation? We may say: "It is because the child *liked* the candy, and wants more," but this is not a physiological statement of what happened to the cortex.

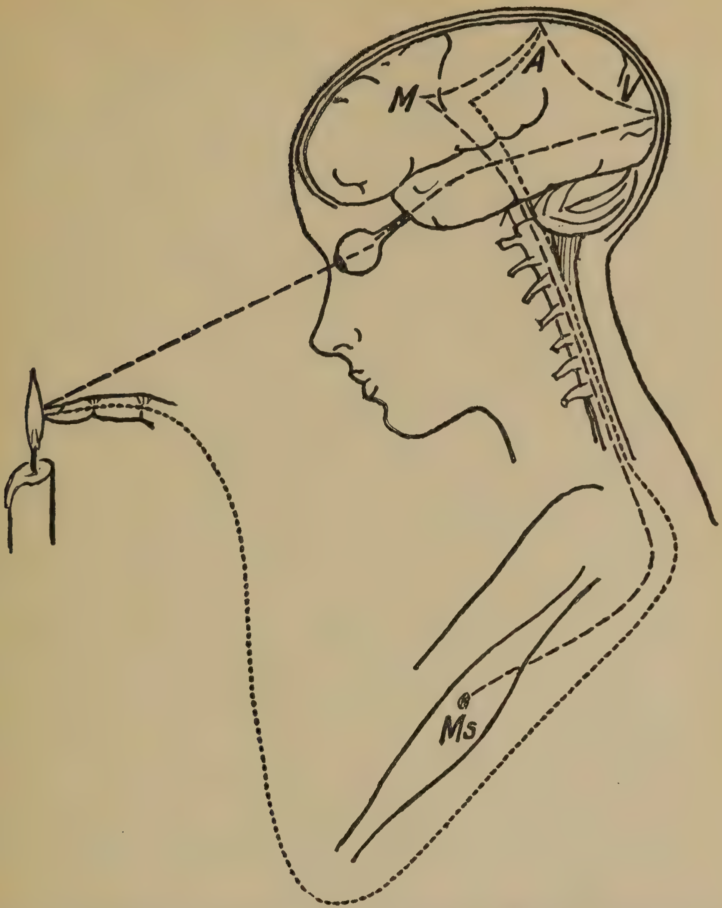

FIG. 11. DIAGRAM TO SHOW THE ACTION OF THE PAIN NERVES IN LEARNING BY EXPERIENCE.

Light from the candle flame stimulates the eye, causing a nerve representation of the candle to be transmitted to the brain. At A an association is formed which initiates nerve currents which leave the brain at M and cause the finger to be thrust into the flame, due to contraction of the muscle, Ms. The flame excites the pain path, shown by the dotted line which sends a current to the brain. When this arrives at A it acts so as to destroy the association between V and M, thus interrupting the response and rendering it less probable in the future.

The first step in developing a proper account of these processes is to note the following facts. The child does not avoid the flame because its skin has been burned, but rather because the nerves of pain were stimulated. The result would be the same, so far as the nervous system is concerned, if fire did not burn but merely excited the pain nerves. A properly graduated electrical shock would have accomplished the same thing, without injuring any tissues of the body. Similar reasoning applies to the case of the candy. The child does not acquire the candy habit because sugar is the fuel of its muscles, but because sugar stimulates certain nerves of taste. These same nerves can be excited even more powerfully by the coal-tar drug, saccharine, which is entirely worthless as a food; but the result is the same so far as the nervous system is concerned.

It follows that there must be something peculiar about the action of the pain nerves and the sweet-taste nerves upon the cortex. The former apparently act so as to decrease permanently the conducting power of certain cortical synapses. The latter act so as to increase permanently such conducting power. Here we find the fundamental principle by which the preferred lines of conduction through the cortex are determined. Whenever a "trial" connection produces a reaction which results in stimulation of a pain nerve, this connection is automatically broken and does not operate again. Whenever, on the other hand, such a connection yields a movement which brings excitation of a sweet-taste nerve, the connection in question is made permanent.

Cortical Encouragers and Discouragers

A survey of many cases of learning shows that the pain nerves and the sweet-taste nerves are not the only ones which are capable of influencing the cortex in this manner. On the other hand, there are many sensory channels which, at least in their primitive condition, are quite lacking in such influence. We can therefore classify all of the sense-organs and their accompanying nerves into three groups: those which discourage cortical connections, those which encourage such connections, and those which are neutral in the given respect. These cortical encouragers and discouragers furnish the natural selective agencies by which the "trials" which are produced by the cortex are formed into permanent habits or else are blotted out. This seems to be what we have been looking for, although we are still far from a complete solution of our problem.

The cortical discouragers include all of the wide variety of nerve channels which are associated with the experience of pain. We have already noted that there are many different kinds of pain sensibilities. In addition to the pain nerves, we may include the bitter-taste nerves as discouragers. Salt- and sour-taste nerves also fall into the same class if they are strongly stimulated. Here must we remark upon the interesting fact that the degree, and possibly the manner, of excitation of a sense organ or nerve may be a factor in determining whether the nerve in question acts as an encourager or discourager. In general, the stronger the excitation the more liable the effect is to be one of discouragement. The discouragers also include the nerve processes which correspond to vile odors. The sensory processes which indicate a distended bladder or large intestine fall in the same class as do those which follow from an empty stomach (hunger) or a dry throat (thirst). The cold-sense of the skin, and the fatigue-sense of the muscles are discouragers. Still other examples might be added.

The sensory *en*couragers of the cortex count as their principal exemplar the erotic or sexual sensibility. This agency is second only in its power to the pain-sense. The erotic sense is not confined to the genital organs, but — particularly in the female — extends to the nipples and the lips. Freud (of whose theories we shall have more to say) claims that in infants it also is aroused in acts of excretion. The nerve activities underlying agreeable odors are in the encourager class, as are those which accompany *weak* stimulation of the salt- and sour-taste sensibilities. The warmth-sense of the skin should also be included. Sometimes the previous state of excitation or non-excitation of a given sense will determine the nature of its action upon the cortical synapses. Thus, the warmth-sense may turn into a discourager after prolonged activity, and the cold-sense under these conditions becomes an encourager.

The reader will notice that the cortical discouragers are excited by agencies which are injurious to the organism, while the encouragers respond to forces which are favorable to its welfare or that of the species. This fact evidently affords the explanation, on the basis of evolution, as to why the specified sensory activities have the respective powers which we have attributed to them. If conditions which tend to destroy the organism did not start processes which would keep the organism out of such conditions, there would be little hope for the survival of the species. Similar statements hold for conditions which are positively necessary for the maintenance of the organism or species. The cortex must be discouraged from carrying out responses which allow the stomach to remain empty, or on the other hand which introduce bitter-tasting, poisonous substances into it. The cortex must be encouraged in responses which reproduce the species. These responses could not be built in by heredity, because their nature must be adapted to the particular environment in which the individual finds himself.

"Neutral" Senses

It is clear that the sense channels which act as cortical encouragers or discouragers all have a bearing upon some special condition which involves the welfare of the organism. Hence, it is to be expected that senses which are not specialized in this way will be neutral in their action upon the cortex. Such senses are concerned in the representation of reality, regardless of its relation to welfare. The principal example of this type of sense is to be found in vision. Hearing is another sense which belongs in the same group. Touch, as contrasted with the skin senses of temperature and pain, is a neutral sense. We must also include in this class, the sense of bodily posture and movement, excluding muscular pain.

Vision, hearing and touch are the principal channels through which external objects influence the nervous system. They supply the majority of the incoming nerve currents with respect to which the cortex makes its random trial reactions. Hence we must say that in the majority of instances the sensory encouragers or discouragers act upon cortical connections between neutral senses and the muscles. Thus, in the case of the child and the candle, a current sent along the optic nerve by the flame image upon the retina sets off a grasping reaction, which is stopped by the consequent pain stimulation. Similarly, in the case of the child and the sugar, the visual current corresponding with the image of the piece of candy causes the cortex to initiate the act of putting the candy into the mouth, and this response is reinforced and formed into a habit by the resulting excitation of the sweet-taste nerves. The common-sense way of stating these facts is to say that "experience teaches us what to do" in any given situation. The purpose of the foregoing analysis has been to see what this phrase means in terms of the nervous system.

The Basis of Habit Formation

It is important to appreciate that the action of the encouragers and discouragers upon the cortex yields a *permanent* result. The child is not merely encouraged by the sweet-taste excitation to keep the candy in its mouth. It acquires a *habit* of eating sweets which will operate — unless interfered with — for the remainder of its life. This fact can only be explained on the basis of our assumptions by supposing that the sweet-taste excitation permanently decreases the resistance of the cortical synapses which connect candy-image visual nerve currents with outgoing grasping-and-eating nerve currents. If the resistance is decreased it naturally stays decreased until something happens to increase it again. Similar reasoning applies to the case of the response to the flame, except that here the resistance is permanently increased instead of being decreased.

It is apparent that this account describes a means by which definite and complicated lines of preferred conduction can be laid down in the cortex. These lines are developed during the lifetime of the individual and hence are acquired rather than inherited. Their nature will obviously depend in an important manner upon the kind of environment in which the indiviudal is placed. Hence the habits of individuals will differ because their life circumstances are different. Early environment will be of particular importance. The personal character of a man is thus to be attributed, first, to accidental trial connections made by his cortex beween specific incoming and outgoing nerve currents (or channels); and, second, to the establishment or destruction of such connections by the sensory encouragers or discouragers, respectively. In addition to the forms of response which are thus determined, we must not forget the existence of those which are due to inborn nerve connections, these being substantially the same in all individuals of the same species.

This attempt to explain in a purely physical manner "why people behave as they do" is admittedly incomplete and introductory. We shall elaborate it and add new principles in succeeding chapters. Our next step, however, must be to turn away from a strictly physical standpoint, to consider the phenomena which occur in consciousness when personality is being molded.

CHAPTER XI

THE RÔLE OF FEELING IN CONSCIOUSNESS

OUR discussion of the physiology of habit formation has made no reference to any part which might be played by "pleasure and pain" as conscious phenomena. Yet everyday experience indicates that these psychological factors play an important rôle. A few simple principles will enable us to deduce this rôle from our physiological account. We can also record what we find to be the facts of experience, and see whether the two accounts agree. If they do, our theoretical principles are probably correct.

The Nature of "Feeling"

The first thing which is necessary, however, is to arrive at a clear conception of what we mean by "pleasure and pain." This conception will need to be more definite and a little more general than the popular one. We shall therefore require a general term to stand for it, and for this purpose we may appropriately select the word "feeling." This word has been used with other meanings, both in scientific and popular discussion, but we shall try to make clear just how it will be used in the present book.

When the child puts candy into its mouth, the sweetness sensation which follows in the child's consciousness is a form of pleasure. Two different aspects of the experience can be distinguished, the sweetness and the pleasantness. We say that the "sweetness is pleasant," as if the pleasantness were an attribute of the sweetness. But pleasantness is or can be an attribute of many other experiences. The erotic sensations are well-known as possessors of this attribute. However they are not so highly praised for this reason as are certain other less "sensual" forms of consciousness. Reading a good story is pleasant. Succeeding in life is pleasant. Doing a benevolent act is pleasant for some people. Pleasantness is therefore to be regarded as a common property of a wide variety of experiences, which may differ radically in all respects except their pleasantness.

When the child puts its finger into the flame, its consciousness is invaded by intense pain. To say that the pain is unpleasant seems superfluous. Yet psychologists are compelled to distinguish between what might be called the "painness" and the unpleasantness of the experience. This is because there are so many other forms of consciousness besides pain which are unpleasant. In everyday speech, we frequently refer to any unpleasant experience — regardless of its nature — as "painful," but it takes no refinement of analysis to prove that this is a metaphor, quite similar to calling any pleasant thing "sweet." The taste sensation, bitter, is normally unpleasant. Losing a contest is unpleasant. Being distracted while at work is unpleasant. Evidently, unpleasantness is a common attribute of many otherwise widely different forms of consciousness. Most of these consciousnesses do not involve "pain" in the strict sense of the word, but we cannot neglect the fact that those which really do contain pain are at the same time unpleasant.

We shall employ the word, *feeling*, to stand for either pleasantness or unpleasantness. Psychologists quite commonly use the word, *affection*, for this meaning, but the usage is so at variance with popular terminology that it seems advisable to avoid it in the present book. The term, "feeling," is sometimes employed to stand for the combination of pleasantness or unpleasantness with whatever it is which possesses these characteristics. Our present use of the word, however, will be in the more restricted sense.

The first feature of interest which we note concerning feeling is its dual nature, its division into polar opposites. Unpleasantness is clearly the opposite of pleasantness as a fact of experience as well as of etymology. The processes of "will" or volition tend to move in opposite directions with respect to the two forms of feeling, and in many instances other accompanying processes are of contrasted character. The second notable feature of feeling is the fact that it varies in *degree*; it behaves like a *quantity*. Thus, pleasantness may be slight, moderate or great; and the same with unpleasantness. It may furthermore be noted that a very low degree of pleasantness or of unpleasantness may be indistinguishable from "indifference," and hence may even be indistinguishable from one another. This indicates that the two opposed phases of feeling come together quantitatively at a sort of *zero* point, which is represented by the indifference state — the absence of feeling, or apathy.

Another interesting characteristic of feeling is its tendency to spread over the whole of consciousness at any moment. As a rule, we attribute the feeling to a limited portion of consciousness, as for example, the sweetness in the case of candy. Our consciousness at the moment of eating the candy includes many other factors in addition to the sweet taste. However, the entire consciousness tends to be pleasantly affected. The pleasantness, so to speak, irradiates over the whole of the conscious field. In many other instances there is no particular portion of consciousness to which we especially attribute the feeling; we are "happy" or "unhappy" in general, and may not be able to explain why. This irradiating tendency of feeling makes it difficult, if not impossible, for opposite kinds of feeling to exist in consciousness at the same time. The same part of consciousness obviously cannot be pleasant and unpleasant at once. Different portions might exhibit these attributes simultaneously, but the irradiation of their "affective" nature makes the existence of "mixed feelings" very rare.

Feeling and Learning

We are now ready to consider how feeling enters into the process of learning on the psychological side. The child who puts its finger into a candle flame experiences at the same time a very unpleasant sensation. This sensation is due directly to a nerve activity which takes place in the cerebral cortex. It is due indirectly to the nerve currents which come into the cortex along the pain channels leading from the finger. The unpleasantness of the sensation must be due — in the same way — to some property of the activity in the cortex. It is an obvious suggestion that the property in question lies in the "discouragement" of the cortical synapses which we have discussed in the preceding chapter. This "discouragement" consists technically in the increasing of the resistance of the synapses. We may therefore consider that *unpleasantness accompanies any activity which augments the cortical synaptic resistance.*

In order to test this hypothesis, let us see whether it works out in all cases. All of the sense excitations which we have listed as "discouragers" should produce unpleasant sensations in consciousness. The taste sensation of "bitter" is unpleasant, as are "sour" and "salt" at high intensity. All three of these sense activities are habit breakers. The skin sensation, cold, is unpleasant and normally it acts to increase cortical resistance. Hunger and thirst are highly unpleasant. The sensations accompanying pressure in the bladder or large intestine are unpleasant. We have already seen that the corresponding sensory nerve currents are cortical discouragers. If we follow through the entire list of these discouragers we find that the forms of consciousness which accompany their action are always unpleasant. Under certain circumstances a given sense may shift from the discourager to the encourager column, but in this event the feeling shifts with it.

If we look at the problem from the side of consciousness, we may now note that there are many types of experience which are unpleasant without involving any of the sensations above considered. This raises the question as to whether these experiences are also associated with an increase in the resistance of cortical synapses. Suppose, for example, that we receive news of the death of a dear friend. The consciousness which follows is extremely unpleasant, but it may not involve any physical pain, bitterness, or any other disagreeable sensation. The "pain" is "mental." If we decide that such "mental anguish" is accompanied on the physiological side by increasing resistance, we face the problem of explaining how the resistance change is produced. An attempt to solve this problem will be made in our next chapter.

At the present moment, however, we must consider the case of "pleasantness." This is a feature of the child's consciousness when a piece of candy is taken into the mouth. We are evidently invited to reason by analogy with the case of unpleasantness, and say that the pleasantness of the sweet-taste sensation is due to the process of *encouragement* which is taking place in the cortex, under the influence of the incoming nerve currents from the tongue. Technically, this encouragement consists in a decreasing of the resistance of the cortical synapses which are controlling the child's response at the given moment. We may therefore contemplate the general proposition that *pleasantness accompanies any activity which decreases cortical synaptic resistance.*

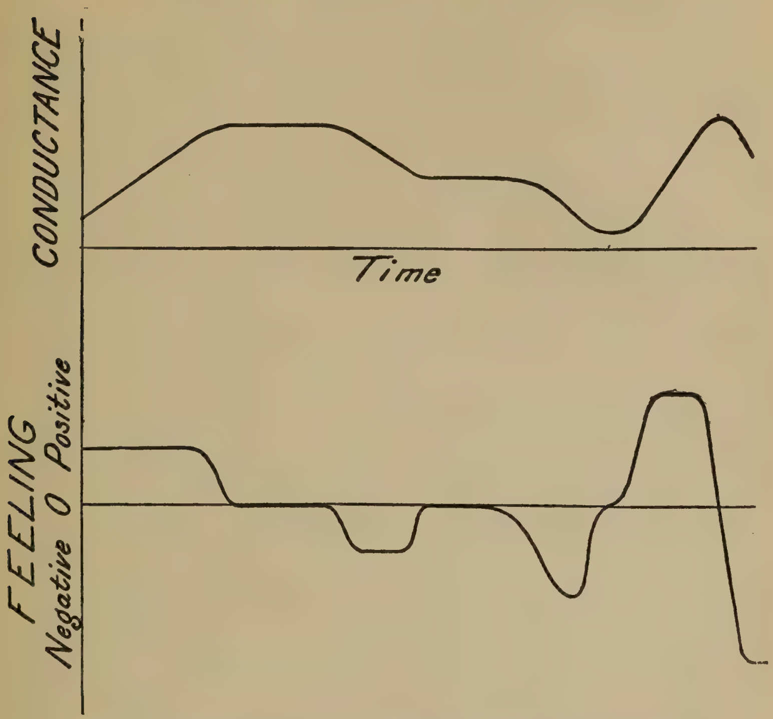

FIG. 12. THE RELATION OF FEELING TO THE BRAIN PROCESS.

The upper curve shows a possible variation of the "conductance" of cortical synapses with time. "Conductance" is the opposite or reciprocal of "resistance," which is discussed in the text. The lower curve shows the accompanying intensities of pleasantness or unpleasantness. These are proportional at any time to the degree of upward slope of the upper curve. When there is no change in the conductance the feeling is zero or "indifferent," regardless of the magnitude of the stationary conductance. When the slope is downward, the feeling is unpleasant or negative.

As a check on this hypothesis, we shall naturally investigate the various sense activities which we have classed as cortical encouragers. Erotic sensation is notorious for its pleasantness, and corresponds with the most powerful of all agencies for reinforcing cortical conduction. Salt- and sour-taste excitation at low intensities belong in the encourager class and are accompanied by pleasant sensations. Warmth as a psychological phenomenon, is pleasant when it is of moderate intensity; and we have listed the corresponding sense current as one which decreases cortical synaptic resistance. Fragrant odors are pleasant and stand for sense excitations which encourage the cortex in what it is doing. Thus, in general, we find that the sense mechanisms which act to encourage the cortex, also produce a form of consciousness which is pleasant.

In the case of pleasantness the same question obviously arises as in the case of unpleasantness. Are pleasures of a "mental" nature also accompanied by a decrease in cortical resistance? If so, we shall have to explain the nervous mechanism which is involved. This explanation will be reserved for the next chapter.

We are now in a position to generalize somewhat further. We have seen that pleasantness goes with decreasing cortical resistance, while unpleasantness accompanies an increasing of such resistance. In general, therefore, *feeling* in consciousness is paralleled by *changes in resistance* in the cortex. Note that the feeling is associated with the process of change, and not with the changed state which results from this process. Thus, *while* the resistance is being augmented there is unpleasantness, but after the change has ceased the permanently high level of resistance which has been established does not occasion any unpleasantness. In the same way, it is only *while* the resistance is being lowered that pleasantness exists, and the consequent reduced resistance is not a condition for this feeling. Feeling is thus related with a purely dynamic aspect of the brain mechanism.[1] (See Fig. 12.)

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[1] If we were interested to do so, we could express the above principle as a mathematical formula. We could call pleasantness positive feeling and unpleasantness negative feeling. We could designate an increase of resistance as a negative change and a decrease of resistance as a positive change. We could then say that the feeling is proportional to the *rate* of change of the resistance. When the change is positive the feeling is positive, and its intensity is determined by the speed at which the change is occurring. Similarly, when the change is negative the feeling is negative, and the intensity of the feeling depends upon the velocity of the change. If there is no change the velocity is zero and is neither positive nor negative, so that there is no feeling, or — more

"Hedonism"

If feeling is the dynamic thing which we have indicated above that it is, it should play a very important part in the determination of action. Every common-sense individual is quite willing to admit that this is actually the case. Sophisticated — probably unduly sophisticated — psychologists, however, have in many instances denied this rôle to feeling. Indeed, some of the psychologists have even denied the existence of feeling itself. Neglecting these extreme sceptics, we may consider some of the historical discussions of the importance of feeling as a dynamic factor in consciousness.

The history of philosophy presents two distinct doctrines concerning feeling. One is the teaching called *ethical hedonism*, according to which the object or purpose of all human action is the attainment of "pleasure" or the avoidance of "pain." This is equivalent to saying that our conscious life should have as much feeling as possible: the maximum of positive feeling and the minimum of negative feeling. In harmony with this doctrine, such words as "good," "ought," "duty," etc., relate to the means for satisfying this aim of all rational behavior. The second historical teaching is called *psychological hedonism.* According to this doctrine, no man can really escape the dictates of "pleasure and pain." In the words of Jeremy Bentham, these agencies are the "sovereign masters" of human action. No matter what we do, we are always seeking pleasure or avoiding pain. The only question which can be raised is as to our efficiency in this process.

Now, ethical hedonists have almost universally based their ethics upon psychological hedonism, so that the latter seems to be the fundamental doctrine. The majority of expositions of psychological hedonism, however, are somewhat lacking in clearness, or at any rate in detail. If feeling is our sovereign master, in exactly what

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strictly — zero feeling. This is the state of "indifference" to which we have already referred. The mathematical treatment could be made somewhat neater by substituting the idea of "conductance" for that of resistance, conductance being the opposite or "reciprocal" of resistance.

However, it is not intended that the reader should be bored with mathematical formulæ, so long as it is possible to express the same ideas in other ways.

way does it control our behavior? Two general types of answers have been given in the past. One of these has said that we are dominated by the *expectation* of pleasure or pain. In contemplating any act, we weigh the future consequences in terms of feeling and choose the alternative which promises the maximum. This doctrine obviously encounters insurmountable difficulties. It necessitates that all conscious behavior should be preceded by rational thought, that it should be "cool and calculating." It leaves no place for the impulsive and emotional forms of action which are so very common. Moreover, the doctrine really states that the *thought* of pleasure and pain, rather than these agencies themselves, is the dominating force. Our calculations are quite frequently in error, so that the anticipated feeling may not be realized.

The second type of answer avoids some of these difficulties by saying that it is not *future* but *present* feeling which dictates our choices. It is not the anticipated pleasure, but rather the pleasure of anticipation which controls us. When there is no thought of the future, and hence no anticipation, nevertheless the impulsive or emotional ideas upon which we act are charged with feeling, and we pick the lines of action which are the pleasantest for the moment. This doctrine is more satisfactory than the first one, but it is still far from agreeing with all of the facts in the case. A thoughtful survey of human life shows that there are innumerable instances in which we are dominated by ideas which have no feeling attached to them. In other cases we are controlled by alternatives which are by no means the most pleasant out of all those which are presented to us.

These criticisms have led some psychologists to reject hedonism altogether, while nearly all students of mind regard the doctrine as only a partial explanation of human conduct. However, there is still a third answer which can be given to the question as to how feeling dominates our choices. We can admit that neither future nor present pleasure and pain are our sovereign masters, and yet we can maintain that *past* feeling plays exactly this rôle. Time is divided into three parts, and for some reason the classical hedonists have neglected to place sufficient emphasis upon the past. Upon general principles, we should expect the causes of our behavior to lie in the past rather than in the immediate present or the future.

Hedonism of the Past

Let us see what this preferred form of psychological hedonism amounts to. Suppose that it is Saturday afternoon. There are numerous ways in which we can spend the half-holiday. We think of golf, of taking a drive, of mowing the lawn, of tinkering with the radio set. Finally we decide upon golf and set off for the links. The older hedonistic doctrines would say either that we expected to have the greatest pleasure at golf or that the idea of going golfing was the pleasantest. The alternative explanation, which we are here advocating, is that our past experience included more pleasure (and less "pain") in connection with golf playing than in connection with any of the other suggested activities. This is why we chose to spend the afternoon on the links. Moreover our choice was determined merely by the historical *fact* of the greatest past pleasure at golf, and not by our present memory or estimate of the pleasure. This means that on the given Saturday afternoon our feeling attitude towards golf might be entirely neutral, and yet we should still choose it.

Of course, the things which have given us pleasure in the past are likely to continue operative in this way in the present and in the future. Consequently, the form of hedonism which we are here advocating is not entirely inconsistent with or contrary to the older doctrines. If golf has been a pleasure in the past, the idea of it will ordinarily be pleasant to-day; pleasant anticipations — and anticipations of pleasure — will follow naturally from memories of pleasant experiences. However, it is well-known that the feeling which attaches to memories is not always the same, and is seldom as intense, as that which characterized the original experience. The memory of painful events is frequently pleasant, or at least may become so when we relate them as adventures to an audience. Nevertheless, the pain of the original experience has taught us to avoid repetitions of the events in question.

In considering this theory, it is important to note that "the greatest pleasantness" is equivalent to "the least unpleasantness." We frequently find ourselves placed in situations where all possible lines of action with which we are familiar, have an unpleasant history. If our brains are incapable of evolving some new alternative act, we will not necessarily be paralyzed but will choose the least unpleasant among the given possibilities. If we regard an increase of pleasantness as the same thing mathematically as a decrease of unpleasantness, this principle will be obvious.

Another corollary of the proposition just stated is that a form of behavior which decreases unpleasantness has practically the same status as one which yields pleasantness. Thus, if I have a pain in the stomach, I try numerous reactions, such as sitting down, lying down, taking medicine, etc., until I finally hit upon one which relieves the pain. This particular, alleviating response, is almost certain to be tried immediately when I have the same kind of stomach pain again. This is because it was the most pleasant of the reactions which were made to the pain; or while the pain existed. In the same way, we may choose, on a Saturday afternoon to cut the grass — instead of knocking a little ball around over it — because we are annoyed by its unkempt appearance or by the wife's objections. Cutting the grass has proven in the past to be the most effective way of obtaining relief in this situation. The decrease of unpleasantness thus procured may have exceeded the gain of pleasantness due to playing golf.

It must be borne carefully in mind that in order to predict a man's behavior, it is always necessary to take the *stimulus situation* into consideration. This is true whether we view the problem from the standpoint of nerve physiology or that of consciousness. All action is in response to stimuli. The stimulus excites the reaction and at the same time limits its scope or range. The stimulus is seldom such that all possible reactions are open to us. We cannot choose the pleasantest of all conceivable responses, but only the pleasantest one under the given circumstances. Thus we cannot mow the lawn unless some stimulus suggests to us the idea of so doing, and we cannot mow it without a lawnmower or equivalent tool.

It should be clear that the doctrine that our choices are determined by past feeling, allows for the establishment of *habits* in which feeling may be quite lacking at present. It is a very unfortunate characteristic of pleasantness that it tends to fade out with repetition of the same act or perception. We tire of a popular melody, of playing Mah Jong, of driving an automobile, etc. Nevertheless, it is just when we have squeezed the last drop of pleasure out of one of these activities that our skill in them becomes the greatest. Hence, there is nothing inconsistent with our theory in the fact that men do many acts without present feeling, or even make choices which are contrary to the greatest pleasure of the moment. Our doctrine is thus capable of harmonizing with facts which the older forms of hedonism — with their emphasis upon present and future feeling — could not meet.

The Measurement of Feeling

In working out this doctrine it is necessary to have a definite conception of how past pleasures and pains are to be compared with one another in degree or amount. Thus, suppose that we are considering two alternative lines of conduct, such as playing golf and listening to radio. There will be a certain quantity of positive feeling A attached to our golf-playing biography, and another amount B of positive feeling associated with our radio-listening history. If A is greater than B, we will choose golf. How shall we measure A and B? Evidently there are two general factors which must be taken into consideration: one, the *intensity* of the feeling and, two, its *duration.* How much do we enjoy a game of golf (on the average) and how many times have we played? Hence, we can estimate the value of A approximately by multiplying the intensity of our pleasure by the number of times we have experienced it. This gives an indication of the degree to which the golf habit has been formed.

Of course, all games of golf are not equally enjoyable, so that it would really be necessary to consider the pleasantness of each game separately, and then to add all of these measures together to arrive at the true value of A. Moreover, separate moments of a single game differ in intensity of feeling. After a good stroke the pleasure is strong, but after a bad one the feeling is on the displeasure side. Therefore, to obtain an entirely accurate result, it would be necessary to estimate the intensity of feeling at each instant during an entire golf-playing biography, and then to combine all of these separate intensity values. Notice that in doing this, the intensities of unpleasant feeling would have to be *subtracted.* All of the positive intensities would be added together; all of the negative intensities would be added together separately; and then the latter sum would be subtracted from the former. A final sum obtained in this manner may be designated as the *amount* of feeling, as opposed to *intensity* of feeling, which latter does not involve duration, but applies to single instants.

We may note in passing that this notion of amount of feeling is substantially identical with the conception of *happiness.* Happiness differs from pleasure in its greater permanence or duration. The same can be said concerning the relations of unhappiness and "pain." We shall have much to say later regarding the psychology of happiness and the part which psychology as a science can play in the pursuit of happiness. At present, we are investigating its foundations.

It is evident that in some cases the amount of unpleasantness which has been experienced in connection with a given kind of response will be in excess of the amount of pleasantness. Consequently, when the sum of the negative feelings is subtracted from the sum of the positive feelings, the answer will be a negative quantity. This obviously stands for so much *un*happiness rather than happiness. Amount of feeling must be allowed to have positive and negative values, just as must intensity of feeling. The significance of negative amounts of feeling for habit formation should be obvious. A line of action which has involved such a negative amount in the past is less likely to be followed than one with which we have had no experience whatsoever. It means the formation of a habit of *not doing* the thing in question.

In reality, the positive, negative, and zero values can be regarded as constituting a continuous series, in which the same principle of comparison applies throughout. Plus two is greater than plus one, and plus one is greater than zero; also, zero is greater than minus one, just as minus one is greater than minus two. Thus, in terms of happiness as a positive quantity, there is no difference between preferring a value of zero to one of minus unity, and preferring a value of plus eight to one of plus seven. In each case we are following the principle of the greatest happiness.

Physiological Relations of Our Hedonism

We must now consider how our psychological hedonism checks up with the principles which we have previously propounded regarding the relationship between feeling and changes in synaptic resistance. We said that pleasantness (positive feeling) goes with the decreasing of such resistance in the cortex, while unpleasantness (negative feeling) accompanies an increasing of this resistance. What do these statements imply concerning the relationships of *amount* of feeling to the cortical process. The implication is very definite, although it is one which it is difficult to demonstrate convincingly without the aid of mathematics. The intensity of the feeling is related to the *speed* at which the resistance is being altered. If the feeling endures only a short time the resulting alteration will be small, but if we add together the alterations produced during a number of such brief intervals the final change will be greater, approximately in proportion to the number of intervals considered. This summation is parallel to that which we carry out in determining an *amount* of feeling. Hence, we may conclude that amount of feeling stands for the *total alteration in the resistance* which has occurred during the history of the given form of response.

Since this conclusion furnishes an explanation of our doctrine of psychological hedonism, it is worthy of further elucidation. We may compare the case to that of a moving automobile. The speed at which the synaptic resistance is changing is analogous to the speed of the automobile, which can be read on the speedometer at any moment. This speed is evidently independent of time, or any particular lapse of time, since the reading may remain the same regardless of whether we merely glance at the instrument or, on the other hand, scrutinize it over a considerable period. The intensity of feeling at any instant is determined by the value of the speed at that instant. We may compare the feeling to the impression of velocity or the thrill which is experienced by occupants of the automobile.

In terms of this analogy, *amount* of feeling would depend upon the distance covered by the automobile between any two instants which we might wish to consider. This distance must obviously depend upon two factors, the speed of the vehicle and the time which elapses between the two instants. If the speed is constant, the distance can be calculated by multiplying the speed by the elapsed time. Similarly, the amount of feeling will be computed by multiplying the intensity of feeling by the time, or by an equivalent process. In the case of synaptic resistance, multiplication of the speed at which it is changing, by the time must yield the total or net alteration of resistance which has occurred during the given interval. The parallel of amount of feeling is thus a kind of "resistance distance" which has been traversed.

Now, we start out in the new-born babe or in the embryo, with a set of synaptic resistances in the cortex which are all practically the same. In order to establish any habits or fixed response tendencies in this individual, some of the synapses must have their resistances moved either up or down with respect to this congenital level. The rate at which this motion is occurring is represented in consciousness by intensity of feeling. The direction of the change, whether it is up or down, is represented by the nature of the feeling, whether unpleasant or pleasant, respectively. The total amount of feeling which has been experienced in conjunction with any given synapse during the life-history of the individual, is an index of the distance and direction through which the resistance of that synapse has been moved from the congenital dead level. It is therefore inevitable, logically, that the measure of past happiness associated with any specified form of behavior should be an index of the tendency of this form of behavior to recur. This is the essence of our psychological hedonism.

The rôle of feeling in consciousness is therefore to represent the rate at which definite forms of response are being built up or torn down at any moment. If the process is constructive the feeling is pleasant; if the process is destructive, the feeling is unpleasant. At the present stage of our thought we cannot say that the feeling is the agency which *causes* the construction or destruction, although this is a possible hypothesis. Thus far we have made no assumptions regarding relations of cause and effect between the physical world and consciousness. We can say, however, that whenever consciousness is pleasantly affected some force goes to work to build up the kind of conduct which accompanies, and which presumably causes or conditions the pleasantness. On the other hand, whenever consciousness is unpleasantly influenced, some agency operates to break down the concurrent behavior and the habits which underlie it.

The above discussion cannot but have aroused some doubts and queries in the reader's mind. Numerous cases can readily be cited to show that the principles which we have thus far laid down are not adequate to explain all of the phenomena of feeling, learning, and action. At least one reason for this is the fact that we have simplified our discussion unduly in an endeavor to make it clear. However, we must now go on to consider some further principles which are necessarily involved in any theory of human behavior and character which pretends to be complete.

CHAPTER X

THE PHYSIOLOGY OF THE HIGHER FEELINGS

IN the previous chapter we have seen that feeling is associated with changes in the resistance of nerve junctions in the cerebral cortex. In an earlier chapter we have learned that such changes can be engineered by special senses which we have called encouragers and discouragers. We have still to ascertain whether there are any other conditions under which the resistance of the cortical synapses is subject to alteration. We can argue that such conditions exist, from the fact that feeling is not restricted to sensory causes. Most of the pleasantness and unpleasantness of adult consciousness is attributable to so-called mental states or processes. The purpose of the present chapter is to consider the principles which underlie such "higher" forms of feeling.

The Law of Exercise

The first principle which needs elucidation is that of *exercise* or practise, which states that if for any reason a nerve current flows through a point of high resistance, the resistance is thereby reduced.

This action may be compared to that by which water by flowing along a certain channel clears a way for itself, so that the flow becomes easier and easier as time goes on. A similar effect can be observed in some electrical circuits, especially in those which contain a spark gap and operate at high voltage. It is characteristic of all such effects that they have a rather definite limit beyond which they cannot be carried. The farther the present value is from this limit the more rapid the change is liable to be, and as the limit is approached the change becomes vanishingly small. Thus the river channel erodes rapidly when it is narrow and the resistance which it offers to the stream is high, but after a time the channel reaches a maximum size and the resistance becomes practically constant.

Everybody is familiar with the fact that repetition of a perception improves our memory of the thing perceived. Repetition of an act yields an increase in facility and skill in this particular act. Both of these effects must be explained in terms of changes in the resistance of cortical synapses. If this is true they must be accompanied by feeling. In the case of learning an act or a complete response, the process will ordinarily be under the control of an encourager or discourager, at least in its initial stages. However, when a habit has gathered some headway — so that its resistance is lower than that of any alternative response — it will not require special encouragement. Nevertheless, its automatic operation may further decrease the resistance. The pathway through the synapse will be worn down until the minimum possible resistance is reached.

It will be seen that when a habit has thus become dominant, its continued operation should be pleasant until repetition no longer strengthens it, after which its operation should become indifferent. The process of *placing* the given habit in the dominant position will not necessarily be pleasant, because this can be done by discouragers as well as by encouragers. A discourager can make a given action tendency dominant by increasing the resistance for all possible alternatives of this action tendency. A careful consideration of the facts will show that our deduction concerning the history of feeling in relation to habit formation is correct. When a given response has acquired sufficient momentum, it becomes pleasant in and for itself, without reference to sensory conditions, but this pleasure gradually wears off with repetition. For example, we may tackle typewriting or stenography under pain of earning a livelihood, but "become interested" in these operations when we have acquired a certain amount of skill. However, this interest is almost certain to lag as soon as there is nothing more for us to learn or achieve in the given fields.

The other application of the exercise principle is to perception. Perception, and its attendant brain activities, do not in themselves necessarily lead to action. Nevertheless, they leave a record in consciousness and in the cortex, which is called a memory. This record must consist in altered synaptic resistances, but the synapses which are involved are evidently not between incoming and outgoing nerves. They are rather cross connections between parallel incoming nerves. They represent different patterns of combination of these nerves, or their contained currents. However, since the activities of these cross-connecting synapses are represented in consciousness by the perception, the changes in their resistances should also be accompanied by an appropriate *feeling*. In general, these changes will be in the direction of a decrease, so that the feeling in question should be one of pleasantness.

The Pleasure of Novelty

The conclusion which is thus reached is that, other things equal, *all novel perceptions will be pleasant.* We say, "other things equal," because the special action of cortical encouragers or discouragers must be excluded. A perception which includes pain as one of its constituents can hardly be pleasant. A perception which embraces sweet-taste or erotic sensation will be pleasant for other reasons than the one which we are now considering. We say, "novel," because repetition of the same perception finally brings the impression which is made upon the cortex to a maximum value. When this condition has been reached there can no longer be any decrease in the synaptic resistance, and hence the pleasant feeling will be replaced by indifference. This is the explanation, in terms of our theory, of the pleasure of new experiences, especially in the realms of sight and hearing, where there is no primary encourager-discourager effect. The principle is not limited to these latter realms, however, but may combine with the encourager-discourager principle in any sense department. (See Fig. 13.)

As examples of this "pleasure of novelty," and the laws which govern it, we may cite the pleasantness of *travel* with its constantly changing sights and sounds. This pleasure "wears off" with repetition of the same impressions in a single location, so that the pleasure-seeking traveller moves on in quest of further novelty. The scientific investigator, or the enterprising business man, finds similar sources of pleasure in the new facts and situations which are constantly developing in his work. The pleasantness of music — particularly of simple melodic or "popular" music — affords another excellent example. A given melody may be very pleasant for the first ten times that it is heard, but at the fiftieth time it is liable to have no feeling value at all. Our ability to remember, and usually to reproduce, a melody increases as the amount of past feeling which we have accumulated in connection with it increases. This amount

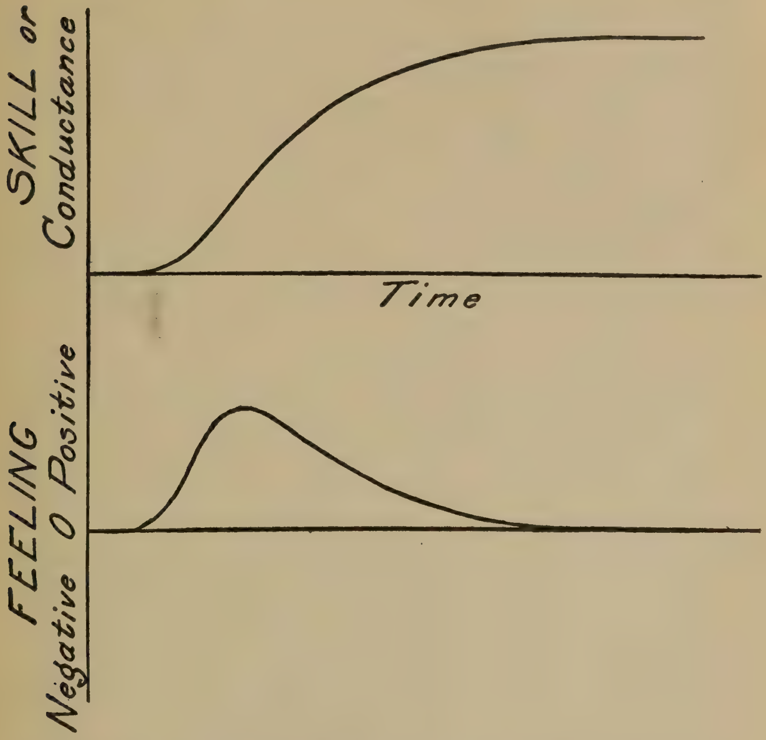

FIG. 13. THE LAW OF LEARNING AND OF THE ACCOMPANYING FEELING.

The upper curve shows approximately how skill in any act increases with time or repetition. The lower curve indicates the accompanying intensity of feeling, in accordance with the principles explained in Fig. 12 and the text.

of feeling reaches its maximum value when the intensity of the present feeling has fallen to zero, and the melody is completely "worn out." Similar statements apply to the other examples which we have considered.

On the purely physiological side, we may regard the exercise effect as being due primarily to the pressure of sensory nerve currents. This pressure is not of the special kind which is exerted by the encouragers and discouragers, but is merely a general pressure which forces the currents through the synapses and breaks down their resistance accordingly. It is doubtful whether the discouragers act specifically upon the cross-connection synapses to any great extent. If they did we should be unable to remember scenes or sounds which were accompanied by pain or other unpleasant sensations. There are some cases of such memory failure, it is true, but they are exceptions to the general rule. Ordinarily, we retain a very vivid memory of unpleasant experiences, and the evidence is strong that when we forget on account of the unpleasantness this is due to "repression" rather than to the absence of a record.

The Law of Decay

Another principle which we must add to the exercise effect is its logical opposite, the principle of decay of impressions due to lack of exercise. When a given form of response or habit is not used frequently, we lose skill in it. Such lack of use may be occasioned by an absence of the stimulus which normally sets off the particular response, or it may be due to other reactions to the same stimulus having secured dominance. Thus, we "forget" how to play croquet when we have not practised the game for a considerable time. This may be because there is no proper ground available on which to play, or because the stimulus which used to lead us to such a ground now sends us to the golf links. Eventually, we not only lose skill in the game, but we become unable even to recall its rules. The simplest explanation of this lapse of skill and knowledge is that the synapses for croquet have gradually increased in resistance during the period in which no nerve currents have passed through them. The process is analogous to the gradual filling in of a river bed through which water no longer flows.

An entirely similar change occurs in the memory impressions which record things which we have seen or heard, but with respect to which we have formed no distinct habits of action. If these memory pictures are not refreshed by repetition of the original experiences — or at least by mental reflection — they become faded and dim and finally disappear altogether. The change which occurs in the brain is probably more involved than seems likely at first thought, since under some circumstances — such as under hypnosis — such faded memories can be vividly rejuvenated. However, we are forced to suppose that the lapse of the memory record is due to a gradually increasing resistance in certain synapses which are essential to its reproduction. These may not be all of the synapses which are involved, but a resistance increase nevertheless occurs in some of the essential synapses. Some recollections fade much less readily than others, possibly because they were originally recorded more strongly, or possibly because reflection has constantly rejuvenated or exercised them.

This principle of the decadence of unexercised nerve channels has numerous important applications. One set of applications is to the practical development of human conduct. If response tendencies decay when they are not used, we cannot tell exactly what a man will do in a given situation simply by ascertaining everything which he has learned in the past through "pain," "pleasure," and practise. We must also consider to what degree various habits have been allowed to lapse. The decadence principle will explain many apparent exceptions to the general principles which we have already laid down. It may be that in early life a certain individual has developed a profound interest and skill in music, but that a change in environment makes impossible the exercise of this set of reactions over a period of many years. In the new environment, a new set of responses becomes powerfully ingrained; let us say that they are directed towards financial success in industry. Finally, let us suppose that the environment changes again so that the stimuli to musical and business activity are presented side by side. The business reactions will probably remain dominant.

It will be noted that the decadence principle coöperates with the law of exercise to increase the dominance of any form of response which has acquired superiority, no matter how small this superiority may be in the beginning. If golf becomes ever so slightly more attractive than croquet, the golf habit will grow through exercise while the croquet habit decays through lack of exercise, the separation between them constantly becoming greater.

Unpleasantness and the Decay Law

The second group of applications of the decadence principle have to do with the *feelings* which accompany the decay process. Now, we have assumed as a general law that any increase in synaptic resistance in the cortex is associated with the appearance of unpleasantness in consciousness. Hence, we should infer that the decay of habits or sensory memories will produce an unpleasant state of mind. However, there is a very important reservation to be made at this point in the argument. *The feeling which goes with the change in resistance of a synapse cannot enter consciousness unless the sensation or image aspects of the activity in the same synapse are also present.* Speaking figuratively, if a synapse is not in consciousness as a whole, none of the aspects of its activity can be in consciousness. Looking at the matter strictly from the psychological side, a memory or a perception cannot be *unpleasant* or *pleasant* unless it is *present.*

These considerations may suggest a trick to escape certain difficulties to be met by our hedonistic theory. However, careful study of the facts in the case will indicate that the considerations are valid. Consciousness—or at least the particular consciousness which we are able to report — is apparently not associated with *all* of the activities which go on in the cerebral cortex. We shall find clear evidence for this belief when we come to consider the sub-conscious mind and the phenomena of multiple personality. Our central consciousness seems to be determined by a group of cortical processes which are controlling the voluntary muscles at the given moment, and particularly those muscles (as of speech) through which intelligent expression is possible. Furthermore, consciousness seems to accompany especially those cortical changes in which active learning is taking place. As a habit becomes more and more fixed the consciousness which goes with its exercise decreases, so that eventually the habit may operate, as we say, automatically — without consciousness.

If we accept these statements, we can suppose that most of the decay of conducting ability in cortical synapses takes place "outside of consciousness." The decay, or increase in resistance, occurs just because the synapses are not being used. To this extent, therefore, we are obliged to qualify our general principle that a man's action tendencies can be predicted from a knowledge of the total amount of feeling which he has experienced in connection with different forms of response. The unpleasantness which should accompany the spontaneous decay of habits may be present in the sub-conscious mind, but is ordinarily not given in the central consciousness of the individual.

However, cases exist in which some of this type of unpleasantness does appear in the central consciousness. When we are in an enforced state of mental inactivity, lacking new stimuli and without any flow of creative thoughts, we usually suffer a form of unhappiness called "ennui." The state of "boredom" is similar to this. Here, stimuli are present which are inoperative upon the cortex, either because they are so familiar or because we are mentally immunized to them. These unpleasant states can be attributed to the spontaneous decay of synapses which are actually represented in consciousness.

The condition of ennui is particularly liable to occur in individuals who have relied mainly upon the pleasures of novel experiences in their past. The brains of such people are filled with saturated synapses which have no direction to move save towards increased resistance or memory decay. The condition is especially serious in an individual of this type who possesses no power of creative thought or imagination. The unpleasant state called lonesomeness is closely allied to ennui and boredom. It involves a brooding upon ideas which have been generated in the past by intense personal stimuli. The absence of these stimuli at the moment removes the necessary support from under the high conducting values which the corresponding synapses have acquired, and consequently they tend to sink spontaneously — even while they are responsible for central features in consciousness.

The Formation of Complexes

The principles of exercise and of decadence can be employed to explain many forms of pleasure or displeasure which are lacking in a clear cut sensory basis. However, these principles are still insufficient to account for all of the facts. The further idea which is needed can be illustrated by reference to our previous cited examples of cortical encouragement and discouragement. When the child thrusts its finger into a candle flame, it learns something more than not to put the finger in again. It learns to *fear* candle flames and other similar objects. This fear is represented in consciousness, at least in one way, by the fact that the *sight* of a candle flame has become *unpleasant*. From this we can infer that the group of optic nerve currents which result from the image of the flame within the eyes, have become capable by themselves of increasing the resistance of cortical synapses. Or, again, let us consider the case of the child and the first piece of candy. As a result of this experience, the child not only learns to reach for candy, but the sight of a sweetmeat gives immediate pleasure. It follows from this fact that the corresponding optic nerve currents have acquired the power of decreasing the resistance of cortical synapses.

The principle which underlies the above instances is evidently the following. Through *association*, based upon an initial experience, any stimulus (or the corresponding sensory nerve excitation) can acquire the powers of an encourager or a discourager. The powers which are acquired are those of the particular encourager or discourager which is concerned in the initial experience. Thus, in the case of the child and the candle flame, the candle-flame sensations take on the functions of the pain sense which is operating along with them. Also, in the case of the child and the candy, the visual sensations which go with "seeing candy" become endowed with the powers of the sweet sense. The system of nerve connections or the nervous mechanism which underlies any combination of this sort may be called a *complex*. We choose this name because the manifestations of the nervous mechanism in question are essentially the same as those of the "complex" as described by the Viennese psychiatrist, Sigmund Freud, in his famous theory.

Principles of Association

Before considering the bearing of our doctrines upon the Freudian theory, we must first discuss some of the simpler relationships of the complex as we have defined it. The first point to be noted is that the formation of complexes is based upon nothing more elaborate or mysterious than the venerable principle of "association of ideas." According to this principle, if two sensations, ideas, or other factors of consciousness, are presented a single time simultaneously, either one of them will be capable, thereafter, of bringing to mind the other. Thus, if we once hear Boston characterized as the home of baked beans, this form of food will tend to make us recall the name of the city when we see it, taste it, or hear of it again. In an exactly similar manner, if we see a bee and are stung by it, the next time that we see this insect — or any similar one — the pain of the sting is brought to mind. The only difference between the two examples is that the pain idea has a very definite bearing upon our behavior at the time, while that of Boston may not have.

Thus far, we have considered the nature of a complex in a general and popular way. We must now study its physiological and its psychological properties separately and a little more definitely. The principle of association is very old as a psychological doctrine, but some modern improvements have been made in the manner of stating the principle. The older method was to emphasize the units which are associated. The newer method emphasizes the structure or combination which results from the association, or — better — which causes the latter. We believe that every moment of action of the entire system of sensory nerve channels impresses itself upon the cerebral cortex in a unified way. If we are looking at a street scene while someone is talking to us and possibly certain odors are reaching our nostrils and we are oppressed by the heat, all of this combines in the cortex — as it does in consciousness — into an integral whole. A principle which is more fundamental than that of association is therefore, that at any moment the cortex operates and records as a unit. The association principle reduces on this basis to the statement that if a portion of such a unitary record is reproduced at any later time, the entire record system will tend to be excited, so that the original unitary consciousness will be rearoused.

In modern times, the association principle has been demonstrated in animal behavior and thus has been given a physiological statement. The Russian physiologist, Pavlov, showed that the secretion of saliva in dogs could be set off by the ringing of a bell, if such bell-ringing had accompanied eating at an earlier time. The natural stimulus to saliva secretion is the odor and taste of food, such as meat. However, associative experience is able to endow an arbitrary stimulus with the same power to start the saliva flowing. In the same way, a cat runs for food when it hears a spoon rattle against a dish, because it has learned to associate this particular noise with eating. We may suppose that exactly the same thing happens to our cortical encouragers and discouragers; through experience, control of them can be passed over to any sensory channel or form of sensory excitation whatsoever. The result is a complex. In fact, the dog to which we have referred has a bell-(food) complex, while the cat has a spoon-(food) complex.

Kinds of Complexes

It will be realized at once that there are as many classes of complexes as there are cortical encouragers and discouragers. Thus we may have pain complexes, bitter complexes, hunger complexes, sweetness complexes, temperature complexes, sexual complexes, etc., etc. Freud and his followers have tended to limit complexes to the sexual, but this is unnecessarily narrow. Moreover, complexes can be complex. Pain and hunger, for example, may be combined as discouragers in a single associative system. A particularly interesting situation arises when encouragers and discouragers are joined in this way. A great many of Freud's cases involve such a union of sex with pain. Here, a stimulus simultaneously arouses erotic desire and fear, with distressing consequences for the individual.

The Freudian literature tends to emphasize and to overemphasize the kinds of complexes which we regard as abnormal or reprehensible. However, as we have defined a complex, there is nothing necessarily pathological about it. A vast number of our most useful and praiseworthy forms of behavior are based upon complexes in the sense in which we have chosen to employ the term. The fundamental principles which are involved are the same in all cases. Whether or not a complex is considered abnormal will depend upon the judgement of society rather than of psychology. If it gets us into trouble, either with nature or with man, a complex is abnormal; if on the other hand it proves an aid in life, it is normal. Thus, to associate pain with poisonous insects is normal and helpful; while to associate it with a nutritious article of food is abnormal. Either association, if formed, would be attributable to some initial impression, which in the last instance cited must have involved some accidental combination of pain and the food substance in question.

The Properties of Complexes

Before considering further special examples, we must examine some of the general properties of complexes in relation to habit formation, or the building up of definite action tendencies through experience. A complex is something more than a habit. It is a habit-former. In the case of the child who has been burned by the candle-flame, the visual stimulus of the flame image has acquired the power to discourage cortical conduction which (power) was originally peculiar to the pain nerves. This means that forms of response which are tried out within view of candle-flames will be discouraged, just as if they resulted in sensory pain. A child may refuse to enter a room or a shop in which candles are burning, and may develop a hatred for persons seen in such places even at some later time when the candles are absent. The room or the person thus become endowed with the pain effect, which can be passed on in this way *ad infinitum.* Its final attachments may be so remote from the original cause of the pain that the latter has entirely disappeared from conscious memory.

In applying these principles to cortical encouragers, we may consider further the case of the child and the candy. The original experience has endowed the visual image of candy with the power to decrease the resistance of cortical synapses. Hence any response which the child tries out in view of candy will tend to be reinforced and made permanent. Going to the candy store soon becomes a habit, even if no candy is secured. The child develops an admiration for the man who owns the candy store, and so on. An elaborate series of preferences can be built up in this way, by a process of pyramiding on the original association, without ever actually returning to the crude sensory impression of sweetness. This can be regarded either as a development of the original complex or as a superimposing of other complexes upon the fundamental one. The result is a gradual evolution of personality which is rooted in primitive experiences of pleasure and pain.

It should be noted that our principle of psychological hedonism is supposed to hold for all stages of this evolution. The growth of action tendencies or preferences is always proportional to the total amount of feeling which has accumulated in connection with them during the individual's biography. In the beginning, feeling is mainly under the control of the "pleasure-pain" senses, but as a consequence of association this control is delegated to agents of a more complex and specific nature. Nevertheless, these substituting agencies are effective in molding action tendencies only in so far as they simultaneously determine the happiness of the individual. The feeling passes from taste to sight, and from one thing seen to another, or to a thing merely thought of; but the value of feeling as an index of learning remains unchanged throughout this evolution.

Instincts in Relation to Complexes

The psychology of complexes is very closely allied to that of instincts and emotions. In fact, in the present writer's opinion, the theory of complexes provides the key to an understanding of so-called instinctive behavior and emotional experience. During the present century, instincts have played a rôle of ever increasing importance in psychological discussion. Some authorities seem to regard them as the basis of all human action. Others deny that the human being has any instincts at all. There is also considerable disagreement as to what is meant by the term, "instinct," and most of the definitions which have been offered are lacking in clearness. It is agreed, however, that instincts are physiological things, and that the corresponding psychological phenomena are to be found in the emotional consciousness. For every instinctive activity on the physiological side, there is a correlated emotional process on the psychological side.

The broadest definition which we could give to the term, "instinct," would make it stand for all of the response tendencies which are *inborn*, as contrasted with those which are learned during the life of the individual. Such congenital response tendencies, or habits of the species, must be attributed to nerve connections which are established by heredity rather than by the processes of learning which we have been discussing above. They are due to the structure of the nervous system, as determined by the germ-cell. The lines of lowest synaptic resistance which govern these congenital responses are not products of "exercise" or of "cortical encouragement."

However, if we use the term, "instinct," to include all congenitally fixed responses, it must cover the so-called "reflexes." These are usually so simple in their nature that they do not correspond to the popular idea of instinct. Thus, winking and sneezing are reflexes; but we do not ordinarily call them instincts. Nevertheless, they are properly described as being instinct*ive*, which means that they were not learned by experience. The question therefore arises as to whether there are any *complex* response tendencies of this class. In lower animals, we seem to find plenty of instances of such complex instinctive actions. The movements of a bee in forming and filling a honey-comb, the nest-building activities of birds, the care which a cat takes of its young, appear to satisfy the requirements of the popular conception of instinct. However, it is necessary to study the lives of the animals very carefully to be sure that no part of these so-called instincts is learned by experience. Such studies are on the whole favorable to the view that complex response tendencies actually are passed on by heredity in most of the lower animals.

When we consider the case of man, we find that there are plenty of simple forms of response which are fixed by heredity. There is no denying the existence of a multitude of innate reflex connections within the human nervous system. However, the evidence for clean-cut congenital action tendencies of a more complex character is not at all satisfactory. The dominance of the cerebral cortex in man seems to have obscured, if it has not eliminated, the complex responses due to the lower nerve centers. The human infant has to be taught many things which young animals seem to know without instruction or experience. Nevertheless, there are numerous fundamental similarities between the behavior of different human beings which suggest an hereditary determination. Thus, we are all subject to the emotions of fear and of love. These seem to be the conscious counterparts of instincts of escape from danger and of sexual pursuit, respectively.

However, a difficulty arises in the fact that the things or the persons which are feared or loved vary so widely between individuals. It is quite evident that although fear in general may have an hereditary basis, the exact thing which is feared depends upon experience or learning. Apparently, we are not born with a fear of anything in particular, but only with a general capacity to fear something. Certain lower animals seem to be born with specific aversions; cats, for example, apparently have an instinctive fear of all large, unfamiliar, moving, furry objects — which are usually other animals. A cat reacts to such objects by hissing, raising the hair and either running or standing very still — according to the proximity and movement of the object in question. Such specific aversions are difficult if not impossible to demonstrate in the naïve human being.

Even if we thus deny the existence of full-formed instincts in man, we still have a way of accounting for the similarities which are observable in the behavior of separate individuals. Although the environment of each individual is special, there are nevertheless a vast number of fundamental similarities between the circumstances surrounding all men. This would tend to mold them all in accordance with the same general pattern but, more important still, the physiological mechanism of learning is the same for all human beings, since this mechanism actually is laid down by heredity. The mechanism in question consists in the trial and error activity of the cerebral cortex combined with the selective operation of the cortical encouragers and discouragers. All men who come into contact with fire inevitably learn to fear it, because from the nature of things it must give them all pain. Fears are simply complexes based upon the pain sense. Love, on the other hand, is a complex founded upon erotic sensibility. Other so-called instinctive types of behavior can be explained in the same manner.

The general doctrine which is suggested by these considerations is that all so-called instinctive behavior in man is an associative expression of the cortical encouragers and discouragers. There can be no objection to calling such behavior "instinctive," since the encouragers and discouragers are inborn systems. Moreover, their initial activities are entirely determined by their hereditary properties. The first time that the child experiences pain, its reactions are independent of previous experience. The second time, however, the experience of the first pain response is involved in the reaction which occurs. Thus, as the nerve paths are built up into a complexity which surpasses that of the simple "reflex arc," learning plays more and more important a part in determining their exact form. Nevertheless, there will always be a core of inherited factors, around which the whole system has been constructed.

Emotions

If we adopt these views, our classification of human "instincts" will follow quite simply from the list of cortical encouragers and discouragers. If we regard emotions as the phenomena in consciousness which accompany instinctive behavior, the fundamental emotionalities can be deduced in a similar manner. On the side of the discouragers, the master agency, pain, will lead to movements of "escape," and emotions of "fear." There will be as many different kinds of escape reactions, and of specific fears, as there are things about us or within us which have caused us pain, or in conjunction with which we have accidentally experienced pain. The unpleasant odors and tastes will yield food-rejecting reactions and emotions of "disgust." Cold will generate a shelter-seeking or house-building "instinct." The corresponding emotion has not been named, but is nevertheless a vivid reality. Hunger, or gastric pain gives rise to food-seeking activities, with the emotion of hunger or of "being starved."

On the side of the encouragers, the pleasant odors and tastes lead to food-taking reactions, and the emotion of hunger satisfaction. Warmth yields rest reactions and "comfort." The erotic sense, chief of the "encouragers," underlies the so-called sexual or reproductive instinct. On account of its importance, nature could afford to make the heredity of this "instinct" rather definite and intricate. However, apparently a great deal has been left to learning and experience, in the human being. It is extremely doubtful whether the preference of the male for the female, and of the female for the male is determined by heredity. In the first place, it is not apparent what the hereditary mental basis of this preference can be, although it is quite evident how experience can teach one to prefer the opposite sex. However, in the second place, in spite of physiological inappropriateness, experience very frequently establishes a preference for a person of the same sex. When it comes to falling in love with a particular individual, this is obviously a condition which is acquired.

We shall continue our application of the principles above developed, in the next chapter. We shall endeavor there to remove certain difficulties which may have occurred to the reader, and we shall pay particular attention to problems of emotional life.

CHAPTER XI

HUMAN HAPPINESS AND PERSONALITY

THE state of human happiness at any time is an index of the direction of development of human personality. Conversely, human personality directs and limits the attainment of human happiness. These general principles are an evident deduction from the views which we have outlined in the foregoing chapters. What is the thing which we call personality? Our reply is that it is the system of response tendencies established by the principles of "learning by experience," which we have sketched above. On the side of consciousness, personality is represented by so-called "habits of mind," or "interests" and by the special emotional tendencies of the given individual. These are the psychological counterparts of habits and complexes.

Hereditary Differences Between Individuals

We have pictured the human infant as starting out in life with a blank cerebral cortex, a variety of automatic reflexes, and a system of sense channels which include encouragers and discouragers. All human infants are much the same, and we should be unable to predict the personalitites which they will develop, by merely determining their hereditary constitutions. However, we must not for this reason suppose that there are no congenital differences between men which are of importance in determining the contrasts which develop between these men in later life. Different lines of family descent will show variations in the general properties of the nervous substance. In some, for example, cortical resistances will be high and will change slowly. In others, they may be low and change slowly, while in others they are high at the start and alter rapidly with experience. Those with high initial resistances will have much to learn by "encouragement," and will be highly susceptible to pleasures; while those of low initial resistances will learn relatively more by "discouragement" and will be more sensitive to unpleasant excitations.

In case the cortical resistances alter slowly under the action of sensory nerve currents, learning will be difficult, and the individual will be apathetic, having relatively little feeling. These are all merely quantitative differences in a general equipment which is the same in qualitative nature for all of the individuals in the species. Hereditary differences of a quantitative nature may also exist in single sense channels, either in the sense organ or in the nerve centers. Inferior vision or hearing may result from congenital conditions and will exert an important influence upon the development of the individual. Even more important in their influence are differences between the encouragers or discouragers. Thus, an individual may be born with an abnormally high sensibility to pain, and consequently may develop a personality which is full of fears and inhibitions. On the other hand, a congenital overexcitability of the erotic sense may produce a sexual debauchée.

In addition to variations of the types above suggested, we must also consider the facility with which the cortex produces trial connections, as a basis for trial and error learning. We may be born with cortexes which are either active or lethargic in this respect. In the former case, we possess more than normal powers of imagination and initiative and we can learn faster than the average man because we make more, and more different, trials. In the latter case, we are apt to be powerless in the face of new situations, and look to other men for guidance. The scientific investigator, the successful novelist, the enterprising business man, are types which develop from labile brains. However, this is again a quantitative difference and does not determine the specific interests which the given individual will acquire, whether he will be scientist, author or entrepreneur, and exactly what problems he will attack in his chosen creative field. These must be settled by his environment, and yet they become built into his personality.

Development of the Child

In the beginning, the child learns and forms his personality almost wholly by trial and sensory pleasure or pain. As preferences become established, exercise plays an increasingly important rôle. Complexes soon appear, at first with an evident sensory history. These complexes take up their work of further molding the embryonic personality. They become sources of feeling in themselves, without actually involving the special pleasure-pain senses. Habits are formed in new situations under the control of existing complexes as well as of the senses in question, and secondary complexes may be established by association with the primary ones. Each step in this process involves the environment in which the individual is placed at the given moment, because each habit and each complex is a linking together of particular stimuli and particular reactions.

It follows from these considerations that the fundamental steps in learning or the education of a child must rest upon sensory pain or pleasure. If we wish a child to form a certain habit, to react to a given situation in a certain manner, we must catch him in the given reaction and then reward him. If he fails to respond in the desired manner we shall be compelled to punish him, until he finally does the thing which is wanted. In this way we discourage all other forms of response except the one required, and when the latter arrives, we especially encourage it. Thus, it becomes the dominant reaction in the given situation, and having achieved this standing will build itself up by exercise until it becomes firmly fixed.

Parents and teachers in using this time-honored method should, however, avoid certain errors in its application which are sure to lead to undesirable results. One of these errors consists in applying the reward or punishment at too remote a time after the response has passed. For example, if we are trying to stop a child from sucking his thumb, we must punish him *while* he is doing this. Any unpleasant stimulus should be effective in breaking up the response; a bitter taste on the thumb or bodily pain no matter where inflicted, so long as it is simultaneous with the act. If we desire the child to come into the house when called, we must wait until he spontaneously reacts to our voice in this way and then should immediately reward the behavior, if possible while it is still in progress, with a piece of candy.

The problem of getting the very first reaction of the desired kind to occur is evidently a difficult and crucial one. The punishment of all other forms of response will obviously aid, but will not necessarily bring forth the required behaviour. Forcing the child's body by pushing or pulling it and manipulating its limbs will not succeed because the action is not then under the control of the child's own nervous system. "Telling" the child to behave in a certain manner will only be effective after words have been learned and have acquired meanings; and even then the verbal command will have little force unless it carries a threat or a promise. Language conveys information but is practically powerless to mold response unless it enters into a complex. We shall have more to say concerning this function of language later on.

Another error which is liable to be made in the use of reward and punishment, is to allow the pleasure or pain to become strongly associated with the person who administers it. Thus if a father punishes his son for a misdemeanor by giving the latter a strapping some time after the event, the principal thing which the son learns is to hate his father and to avoid him. The only way of escaping this consequence is through the feeble instrumentation of words, by the use of which the father assures the son that the punishment is due to the misbehavior and not to ill will. If possible, the punishment should follow automatically and naturally from the act. Similar considerations apply to rewards. Many parents and some teachers have a tendency to overemphasize punishment and to neglect rewards. If the two methods are used about equally, the attitude towards the person who administers them should be approximately neutral in the end. This person will be loved as much as he is hated, but the selection among the various forms of response which have been influenced will be none the less definite.

The Rôle of Language

The part which is played by language in education and the development of personality is a very important and interesting one. The meanings of words can obviously be established by mere association. We hear the sound and see the object for which it stands, simultaneously. Afterwards, the sound will recall the object and *vice versa*. Similar considerations hold for written words and for the identification of written and spoken words. The method by which a child learns to speak is probably more a matter of trial and error than it appears to be. Merely hearing a certain word gives the child no information as to how to innervate his vocal muscles to reproduce the sound. He must make sounds at random until the right reaction is hit upon, and this must be sealed in by a pleasure process. The procedure is the same here as elsewhere; when the proper response appears it must be rewarded and other responses must be punished. Success in vocal imitation may be a sufficient reward after certain complexes have been formed, but not in the beginning.

Many children exhibit the annoying characteristic of understanding commands perfectly, but at the same time of paying no attention to them: of failing to "mind." Such failure is evidently not due to lack of intellectual association between the words and their meanings. It is rather attributable to a failure of the words to set off either a habit or a pleasure-pain process. If there is no habitual response to the words of command, this is because the child has experienced no predominant pleasure or relief from pain in conjunction with these words in the past. If no pleasure or pain is aroused by the words, themselves, there is no chance that their use will alter the child's reactions at the given moment, or change his action tendencies for the future.

It is evident that words in themselves have no inherent power of giving pleasure or pain. They are auditory or visual things, bearing no innate powers of encouragement or discouragement. Yet, experience endows them with tremendous potentialities of this sort. A few words can submerge us in the depths of misery or elevate us to heights of ecstasy. It is evident that they can acquire this power only by association with more direct pleasure-pain experiences. One word which is quite definitely associated with pleasure is the word p-l-e-a-s-u-r-e, and with pain the word p-a-i-n. The name of each sensation or feeling must be associated with the sensation or feeling in question in order to be able to denote it. On the physiological side, these words must constitute stimuli which are capable under the right conditions of setting off processes of encouragement and discouragement. Thus, when a bully tells a companion that if he does a certain thing he will "get hurt," these words may suffice to stop the act.

Belief and Moral Suasion

Words are effective in this way when they are *believed*. But it is probably more logical to say that *if* words are thus effective, they are *thereby* believed. Belief has to do essentially with language, or with "things which are told to us." If we react to the words as we would to the things which they purport to represent, this is the essence of belief in the words. The process of belief provides a very important secondary mechanism by which encouragement and discouragement are controlled. Thus, if I say to a man with a glass of dark liquid before him: "Drink that and you die," he will ordinarily desist from drinking unless he has reasons for disbelieving me. If, on the other hand, I say: "Drink this and you will feel better," he will tend to imbibe the liquid. However, belief must compete with habit and with cortical encouragement or discouragement, when these factors are also present. If the liquid has the odor of an alcoholic beverage, and if the man is a drunkard, he may drink it even if he believes that it contains poison. This is the type of struggle between "faith" and "temptation" which has received so much attention from religious teachers.

The words which directly describe pleasant and unpleasant experiences are not the only ones which have an associative grip upon the processes of encouragement and discouragement. Words of moral suasion or dissuasion have a similar power with the majority of people. To condemn an act as "bad" or "wrong" or "evil" is to discourage the act, while to praise it as "right" or "good" is to encourage its performance. What these morality terms mean practically to most people is the approval or disapproval of the human group or groups of which they are members. Such approval or disapproval has important implications in terms of actual pleasure or pain. If our acts are evil, we are apt to land in jail or be shunned by our fellow men. If our acts are good, we are rewarded with material goods and the respect of our fellows. Words which indicate success or failure in particular situations have a similar power to mold our behavior. For example, if we tell an ambitious young business man that a certain act which he has been contemplating indicates poor executive judgment, this will discourage him in the act, if he believes our statement.

In training the youth, it is obviously important that moral terms should be brought into definite association with sensory pain and pleasure, in order that later on they can act effectively as character formers. This is done in common practise, by telling a child that he "ought" or "ought not" to act in certain ways, and punishing him if he fails to follow the moral dicta. Obedience may also be rewarded by pleasure. In this way moral complexes are built up, which are set off by the appropriate words. Individuals who are not susceptible to moral suasion, and are apt to belong to the criminal class, failed to acquire these complexes in their early youth. The operation of the morality words is an example of associative encouragement or discouragement which has a hidden mechanism. Very few of us clearly realize that the power of these notions over our behavior is at bottom only that of our "sovereign masters," pleasure and pain.

Changes Due to Age

The younger a person is the more do his processes of character formation depend upon primary sources of pain and pleasure in sensation. These primary agencies are of course continuously active throughout life, but the greater the number of complexes which they form with other kinds of nerve activity the less important their rôle becomes. In walking about in a new house, an adult may learn to lower his head in certain places because in passing through them he bumps his head. However, he is much more liable than a child is to lower his head because he recognizes the danger through vision. The general architectural arrangement which he sees before him suggests pain and the suggested pain inhibits the upright posture. Thus, we go on building up our system of responses in the majority of instances without direct contact with the primary sources of feeling which we have called the sensory encouragers and discouragers.

It is natural that this proposition should be less true for the encouragers than for the discouragers, because experience teaches us to seek stimulation of the former and avoid that of the latter. The enjoyment of good food teaches us to continue seeking it. Erotic pleasure leads to the quest for repeated erotic experiences.

However, the associative sources of pleasure are constantly increasing as the personality of the individual becomes more and more complex, so that relatively if not absolutely, the direct sources play a diminishing part. Persons whom we regard as having well developed and refined natures tend to disregard simple sensory pleasures. Even in the domain of sex, things seen and heard become important sources of pleasure and influence, as proven clearly by the popularity of erotically suggestive pictures, stories, costumes, and stage presentations.

As a person advances in age, certain physiological changes occur which have an important bearing upon the development of his personality and upon the means of happiness which are available to him. One of the most important of these changes occurs at puberty, when erotic sensibilities are markedly heightened. This general change is determined entirely by congenital forces, but its exact outcome for the individual will involve his reaction with the given environment. Later in life, the erotic sensibility decreases, and the capacity for sensory pleasure may disappear entirely. The reflexes associated with the sexual function may become inoperative. Under these conditions, sex habits which directly involve these reflexes and excitations must necessarily remain unexercised. However, other habits having an erotic foundation may remain unaffected. Thus, the age of the individual helps to determine what his effective means of habit fixation shall be, and what habits which have already been prepared in the past shall remain operative.

In addition to the special changes which are associated with the reproductive function, there are other more general alterations which come with increasing age. One of these is the well-known decrease in ability to learn new things. This must mean that the resistances of the cortical synapses tend to become fixed or hardened with time, so that the same forces have a lessened influence upon them. It is in harmony with our doctrine that this change should be accompanied by a reduction in general intensity of feeling, whether pleasant or unpleasant. Another reason why it is so difficult to "teach an old dog new tricks" is that he has already learned so many tricks in his youth. The supply of fresh synapses to be worked on has been appreciably reduced, and a new habit is very apt to conflict with some form of response which is already very thoroughly ingrained.

The principles of personality development which we have suggested above evidently allow for a wide variety of products. Special circumstances will utilize these principles to form widely different kinds of response systems. The general physique of the individual will play an important rôle in determining the end result. An environment which is dangerous and cruel may make a coward out of a weakling, and a heroic character out of a strong organism. Rewards of pleasure based upon actions which are appropriate to success will lead to further success and a constant accumulation of practical strength of character. However, if such rewards follow accidentally from behavior which is not adequate to bring them again, the outcome will be later failure and a disintegration of morale. Strong personalities are those which have been consistently built up on a coherent foundation, in which the pull of pleasure and the push of pain are in the same direction, when this is the direction which leads to success.

Egoism vs. *Altruism*

In practically all individuals, the entire system of complexes tends to center around the idea of one*self*. The natural operation of the pleasure-pain senses is directed towards the welfare of the individual whose senses they are. A possible exception to this statement is found in the case of sex, where the biological purpose is the production of a new individual. However, the motive which appears in consciousness is selfish pleasure. Thus, all of my complexes operate primarily to bring me pleasure and to enable me to avoid pain. The system as a whole may be regarded as forming a self or ego-complex, because of this common tendency of all of its components. However, there is another somewhat different type of ego-complex which has to do with a man's relation to his fellow men. The more highly we are esteemed by others, the better are our chances of a happy life. The mining engineer with the greatest reputation in his field will command the highest salary. Hence, we easily learn to regard ourselves as superior to others in one way or another. Although we may not realize the fact, this vanity is an attempt to raise our bread and butter standing in the community.

The above statements are not meant to imply that all of our behavior is necessarily selfish in its intention and outcome. It is only true that the forces which control us necessarily operate through our own feelings. The ideas and acts which these feelings support may in many cases be highly altruistic. The care of a mother for her child is determined by her own feelings rather than by those of the child. She feeds, clothes and watches it carefully because this is the behavior which gives her the greatest happiness in the home circle. Nevertheless, all of her acts are intentionally and as a rule are really beneficial to the child. In the same way, a great statesman or religious teacher follows the line of conduct which has given him the greatest satisfaction in the past, although his intellectual intentions may be couched wholly in terms of the welfare of his nation or his race. In democratic countries, men who are in the public eye are placed in a situation where at least an apparent interest in the public weal is a prerequisite of their own happiness.

Repressed Complexes

Thus far, we have said very little concerning those so-called abnormal elements of personality which Freud calls repressed complexes, and which have been most emphasized in the discussion of complexes in general. These undesirable factors are due to a conflict of tendencies, depending upon the simultaneous association of pain and pleasure with a single idea. Or to put the situation physiologically, the same response has been both strongly encouraged and discouraged. For example, a child may develop the habit of solitary sexual gratification, and be discovered in the practise and punished severely. If the pain is made more intense than the pleasure, the habit will be interrupted, but the associative connections will remain. The habit will tend to recur but will be stopped by fear. The resulting conflict will distract the mind and divert its energies. As Freud points out, civilization and even nature enforce repressions upon practically all individuals, especially in the case of sexual reactions.

A state of repression exists when a complex is unable to get direct representation in consciousness. In this condition the complex may still be able to influence the individual's behavior, so to speak, surreptitiously. Consciousness may also be affected in a similar manner. A repressed complex acts as if it were part of a separate personality, carried in the same brain as the primary personality and interfering with the activities of the latter. Sometimes this apparently separate personality becomes quite involved and well organized, so that we feel justified in believing that we are dealing with a case of "*dual* personality." More than two such systems are possible and exist in cases of "multiple personality." The normal human mind is in a condition of incipient or partial dual personality. The amount of duality varies from one individual to another. Some people have a great store of repressed complexes — things they would like to do but dare not — while others have relatively few.

Freud explains a large number of mental phenomena as results of the action of repressed complexes. Many lapses of memory are to be accounted for in this way. Suppose, for example, that I have been injured by Mr. A, but that I am compelled to remain on apparently good social terms with him because he is a member of my lodge. In making out a list of members of the lodge, I inadvertently (?) omit his name. Slips of the tongue and of the pen have a similar explanation. Suppose that I have sworn off on smoking because my physician tells me that I have a smoker's heart. I enter a drug store intending to ask for a soda. Instead, I ask the soft drink server for a smoke. The combination of the store (where tobacco is sold) with the "s" and "o" in "soda" set off the old habit, without any reference to conscious intention. Phenomena of this kind strengthen our belief that the sub-conscious mind is a reality.

The Nature of Emotion

The question as to the nature and cause of *emotions* is closely related to the problems which we have been considering above. A very plausible view regarding emotions is that they are the conscious expression of instincts or instinctive tendencies. If we define instincts as physiological mechanisms, then emotions are the corresponding psychological activities. Hence, if we adopt a fixed catalogue of instincts, the list of emotions will be determined accordingly. For example, there will be the "instinct of escape" to which belongs the emotion of fear; the "sexual instinct," carrying with it the "emotion of love," and so on. However, the interpretation of instinct which we have advocated in the present book, allows a somewhat freer treatment of the problem of the emotions. According to our view the central features of human instinctive behavior are the cortical encouragers and discouragers, the pleasure-pain senses. Emotion should accompany their operation under certain conditions.

A survey of the facts leads to the conclusion that emotion arises when we face a situation which strongly excites the pleasure or pain sensibilities but *for which we have no well prepared reaction.* In such a situation we are compelled to institute a process of trial and error and learn an appropriate response. When such a response becomes settled the emotional consciousness or experience disappears. As an illustration, we may consider the case of a baby who is being pricked by an open safety pin. The infant cries violently and wriggles about until relief is obtained. An older child has learned how to react to a pin prick so as to get rid of it immediately, and so experiences less emotion in connection with such a stimulus. Or, consider the case of an adult who finds himself face to face with a bear. If this is the first encounter with such a wild animal and if the man is unarmed, he will experience extreme fear. However, if the man is an experienced hunter provided with a gun, he has his reaction ready and the emotion is absent. The unpleasantness which is aroused by the sight of the bear is evidently produced by association rather than by direct stimulation of the pain sense.

A rather clear-cut example of an emotion due to lack of preparedness is the "fright" or "surprise" which is occasioned by the sudden appearance of a person or an animal where none was expected. If you believe yourself to be alone in the house, and someone enters your room, you are startled. This is because all responses to persons have temporarily been eliminated. As soon as these responses are reinstated, the shock subsides. Sorrow, due to the death of a friend or relative, can be attributed to the impossibility of any adequate or even useful reaction to the event. The bereaved person may exclaim, "What shall I do? What shall I do?" but there is nothing that can be done to alleviate the unpleasantness of the situation. The loss of a close associate places us in a position where we must relearn a very large number of responses. The habits which we have formed about him must lapse, and others must be built up to replace them. When this reorganization of responses has been accomplished the sorrow disappears.

Psychologists have indulged in a great deal of discussion concerning the exact nature of the emotional consciousness. The majority of psychologists have agreed that feeling is an essential part of emotion. They have believed that emotional consciousnesses must be strongly pleasant or unpleasant, regardless of their other characteristics. William James, however, advocated the view that the essential feature of an emotion is to be found in certain organic sensations, which are absent in the normal consciousness. James asserted that "we are sorry because we cry," rather than the converse. In other words, a stimulus causes tears to flow and the sensation of *lachrymation* constitutes the substance of the emotion. An emotion also involves a sense of strong muscular activity or tension. Feeling may be present, but is not essential.

It will be appreciated that the positive side of this Jamesian theory is quite in harmony with our own account of the conditions which underlie emotion. When a pleasure or pain sensibility is excited, definite muscular reactions are set off in a purely "reflex" or mechanical way. Thus, extreme pain causes the shedding of tears; and with fear there is quickened breathing and heart beat. These organic processes arouse corresponding sensations in consciousness. At the same time there is a general release of energy from the cortex, representing an attempt to find a successful method of meeting the situation. Since there is no well prepared channel through which the outgoing nerve currents can flow efficiently, they tend to overflow diffusely into all of the muscles. This results in a general state of bodily tension which is reflected by the corresponding sensation in consciousness. The condition of general tension is most marked in the intervals between "trials" at meeting the situation. These are the periods during which "we can think of nothing to do."

It is evident that the present writer does not agree with James' contention that feeling is not an essential part of emotion. This disagreement will probably be shared by the reader.

If we regard the problem of emotion in the manner suggested above it is not necessary to limit the catalogue of emotions to a list which is restricted by the number of supposed instincts. The emotions of a child would be limited in the beginning by the simple sensory sources of feeling. However, as complexes are formed, the stimuli to feeling become more numerous and varied. The nature of these complexes will be determined by the particular experience of the given individual, and the possible emotional consciousnesses will vary accordingly. The exact circumstances in which a given complex is excited must also be taken into consideration. Thus a fear may be realized or on the other hand, the threatened danger may fail to materialize. In this way either despair or relief may result, as emotions having a single complex as a basis. In the same way, a desire may lead either to satisfaction or disappointment.

The Rôle of Thought

Something should be said concerning the part which is played by thought in the development of personality and in meeting situations in the interests of happiness. Thought is not a unique and mysterious activity of mind. There are many different kinds of thought and the way in which they work is fairly obvious. Most of our thinking is mainly *reacting*. We sit down to think with a paper and pencil. When we write various words and numbers we are reacting muscularly to some stimulus which has "set us thinking." Sometimes we think by talking to someone, and this is again a muscular reaction. The same is true of "talking to oneself," which is a moderately efficient way of thinking. However, it is quite possible for thinking to be carried on exclusively in the brain and in consciousness, without overt expression. In this case we have some of the conscious processes which might accompany listening to ourselves talking, without the talking actually occurring. The talking is inhibited, probably with considerable difficulty.

Thought is essentially the same in function as language. It is a symbolic representation, using words or other signs, of something besides itself. Such representation is made possible by the principle of association. There are apparently two general methods of solving a practical problem by the application of thought. One is the so-called method of logical deduction, of which a good example is arithmetical computation. This method never teaches us anything which is fundamentally new. It merely enables us to tranform knowledge which we already possess into a formula which may have improved intelligibility. Thus, if we know that a plot of ground is a rectangle and has sides one hundred feet and sixty feet, respectively; we can compute its area as six hundred square feet. But this is merely another way of stating the same geometrical characteristics of the plot.

The second method of thinking is that of symbolic "trial and error." The first step is the most difficult. It consists in "thinking of a new idea." The second step is to "see if it will work." This second step may consist in actual experimentation, or it may only be a matter of drawing diagrams. It may even be reduced to a process of bringing forward verbal statements which bear upon the "new idea," to see whether they are consistent with its applicability. In any event, the idea goes through a period of criticism and is either accepted or rejected. The experimental method tests the idea by putting it immediately into full action. The other methods accomplish a similar result less conclusively by means of a symbolic representation of an experimental test. Their advantage over the experimental method is that they are quicker and cheaper. Hence, men who can think new thoughts and test them symbolically so as to imitate the outcome of actual practise, are men who succeed quickly and more completely than do others. The scientific control of life consists in supplying the imagination with a maximum number of accurate facts about the world; and then testing imagination's products with similar facts.

Intelligence and Planning for Future Happiness

Our doctrine that human personality and behavior rest upon past happiness or feeling as a motive seems to conflict with the ordinarily accepted idea that our motives lie in the future. The ability to think is supposed to enable us to regulate our present actions in the interests of future happiness, and behavior which is thus controlled is characterized as "intelligent." Now, psychologically, it cannot be true that motives lie in the future, because a man's constitution — which determines his behavior — is a product of the past. The future, which has not yet come into existence, cannot influence action. It is only our *present* expectation of the future which can operate in this way, so far as the future is represented at all in the situation. Nevertheless, the greater a man's intelligence and "foresight," the greater the part which such expectation seems to play in determining his conduct. How is this possible?

It is possible only because in the past, such intelligent planning for happiness has actually resulted in more happiness than have alternative procedures. Planning for happiness is a form of action. If such planning is based upon facts it is bound to succeed. This type of action will therefore summate more happiness on the average than will any other type.

In this way the organization of behavior in the interests of future happiness can become a habit; and it is a kind of habit which — once started — tends to perpetuate itself because it is constantly reinforcing its own motive power. It is like a steam shovel digging coal out of a mine. It can never lack energy for its own operations and provides the power for other machinery as well. Such intelligent direction is never exclusive of other interests because it ministers to other habits at the same time that it is perpetuating itself. The origins of intelligent control are to be looked for in the same kind of processes which generate all kinds of initial activities. In the beginning, intelligence is merely a "trial." In general it is a difficult trial to make, because it involves relatively complex brain mechanisms. Animals and children show very little evidence of it. The majority of adults cannot learn it by mere suggestion from others, but must be forced to it as the only successful alternative when all others have failed.

Such failure does not consist as a rule in the non-fulfillment of expectations, but rather in the low degree of happiness which accompanies the "unsuccessful" acts. Because of this low degree the acts in question do not develop any appreciable motive power and do not become permanent habits. On the other hand, in so far as acts are based upon truth and are directed thereby towards the attainment of happiness, in so far will they accumulate a history of happiness successes. And so they will become permanently installed in our repertory of preferred lines of conduct. It follows from this reasoning that our doctrine that psychological motives consist in past happiness necessitates that men should form the habit of planning for future happiness. In addition, it follows from our theory that men will act automatically in the interests of future happiness in so far as experience in the past has taught them anything at all, if we suppose that the conditions for the realization of happiness are the same in the future as in the past. Intelligence consists not only in planning for happiness on the basis of proven facts, but in possessing habits of action which are the natural outcome of representative experiences.

CHAPTER XII

THE PHYSICS OF NERVE ACTION

IN the last few chapters we have been considering some psychological problems which are of a common-sense and practical nature. We must now return from these to delve once more into questions of a more subtle kind, which are seldom considered in popular conversation. An examination of these questions is required for an appreciation of the mystery of mind in its entirety. The knowledge which comes with an answer to such questions is essential to any attempt to solve the mystery.

We must first remind the reader of the principles which have already been set forth in earlier chapters. Let us recall that consciousness is the central fact of mind. Let us remember that consciousness and the material world of physical science are two entirely different and separate things. Let us not forget, however, that these two systems are bound together by laws, so that the changes which occur in one seem to be determined by those which take place in the other. The particular small part of the physical world upon which my consciousness seems to depend is a group of nerve activities located in my cerebral cortex. It is within this cerebral cortex that my personality is built up along the lines laid down in the preceding chapter. If we are to understand the foundations of consciousness we must know the intimate nature of the cortical mechanism. It is not sufficient to talk vaguely of synaptic resistance and nerve currents. What is this thing called synaptic resistance? What is the real nature of the nerve flow?

Before we can intelligently seek for an answer to these questions we must appreciate what the general character of such an answer must be. It must inevitably be couched in terms of modern physical theory. This is the theory which we have sketched briefly in the third chapter of the present book. It represents the physical world as a vast, intricate whirligig of electrical particles, protons and electrons. These particles exist in space and time, and they act upon one another at a distance by means of so-called electrical and magnetic fields. These fields, of varying strength, bind them together into aggregations of varying complexity. The simplest aggregation is the hydrogen atom, while the most complex one is probably the human body. Within the human organism the most intricate organ is undoubtedly the cerebral cortex. The cortex and all other parts of the nervous system are fundamentally nothing but combinations of electrical particles, and hence the ultimate account of nerve action must be given in terms of electrons and protons.

To develop such an account would have been a very difficult task not so many years ago. At present, however, we are in the happy position of being able to "explain" nerve processes in fundamental terms in a fairly satisfactory manner. Of course, a great deal still remains to be learned but the mantle of mystery has been removed from many aspects of nerve function by recent investigations.

The Physical Structure of Nerve

We must begin our explanation by recalling that a *nerve*, such as we can find by ordinary methods of dissection, is a bundle of very fine threads known as nerve *fibres*. These fibres are of various diameters but are all so small that they cannot be recognized individually without the aid of a microscope. Each one of them is a living cell which has been drawn out into highly elongate form. Nevertheless it still retains the general characteristics of such cells; it has a generally liquid substance, but with suspended solid particles such as the cell nucleus, and the whole is surrounded by a membranous envelope. When we say that the cell is "living" we mean that it has a very complex chemical constitution, which enables it to undergo certain changes and yet afterwards restore its original condition by absorbing and assimilating fresh supplies from the world outside of itself. In the case of the nerve cell, these changes constitute the nerve current or process of excitation. (See Fig. 14.)

A chemical analysis of the liquid substance of the nerve fibre reveals the presence of considerable quantities of carbonic acid. This is the same substance which gives soda water its sting, and is pro-

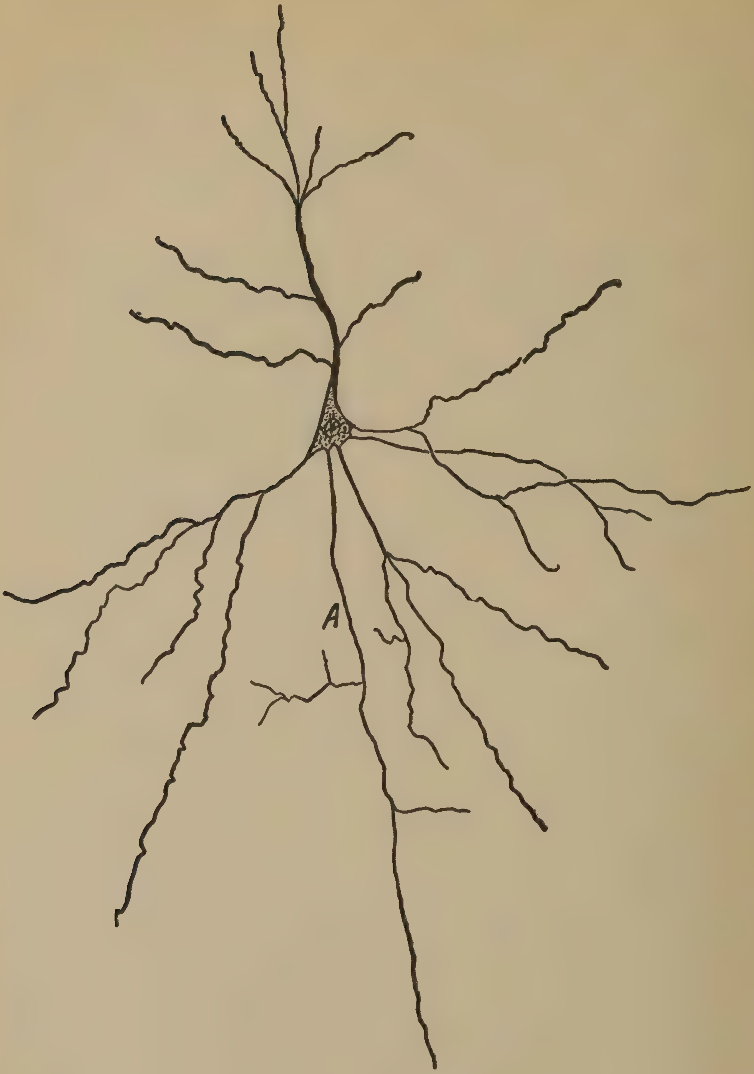

FIG. 14. A NERVE CELL. (After Quain)

The nerve cell consists of a cell-body, with a number of collecting fibres or dendrites. The fibre, A, is the "axon" or outwardly conducting fibre, groups of axons making up "nerves." The axon of this particular cell actually extends a relatively enormous distance in comparison with the small section of its length which is represented in the figure.

duced by respiration. Carbonic acid is made up of molecules which contain three kinds of atoms, those of carbon, hydrogen and oxygen respectively. Each of these atoms is of course composed of electrons and protons. The hydrogen consists of one particle of each kind, as already noted; while the carbon has twelve and the oxygen sixteen of each. When carbonic acid molecules are in the presence of water molecules, they break up in a peculiar manner. The single proton which belongs to the hydrogen atom separates from the remainder of the molecule and floats off by itself. Since the hydrogen electron stays with the carbon and oxygen, the latter have an unneutralized charge of negative electricity. The proton, on the other hand, has or is a corresponding positive charge. Thus the liquid body of the cell is provided with a large number of free or uncombined electrified particles, one type of which is very tiny and the other very much larger. (See Fig. 15.)

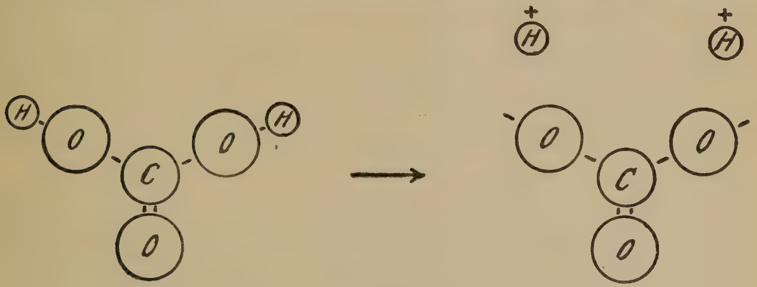

FIG. 15. THE IONIZATION OF CARBONIC ACID.

The left-hand portion of the figure represents a single molecule of carbonic acid, while the right-hand side shows the three particles into which it disintegrates when in the "ionized" condition.

All of these particles, whether or not they have unbalanced electrical charges, are in a state of rapid vibration, which represents the heat energy of the cell. In the course of this vibratory motion they collide with one another and are continually altering their relative positions. It is natural that the smaller particles should slide past their neighbors more readily than do the larger ones, which have a far greater volume and more projecting points. The particles are confined within the boundaries of the cell by the surrounding membrane. However, this membrane must itself be made up of molecules, and hence must be porous to some extent. Very minute moving specks such as the hydrogen proton, or "ion," should be expected to pass through the pores or interstices between the membrane molecules. The larger "carbonate ions" will pass through with greater difficulty, if at all.

"Polarization"

The practical outcome of these tendencies is that the protons or hydrogen ions sift rather freely through the membrane while most of the carbonate ions are held back inside of the fibre. It might be thought that the protons would wander away from the neighborhood of the cell altogether, but this is not the case. The positive electricity which they contain causes them to be attracted to the cell, because the latter still contains the negative electrical particles with which they were originally combined. The result is that an adhering layer of positive particles (the protons) is formed all around the outside of the cell. The negative (carbonate) particles are attracted in turn by the positive particles so that they hug the inside of the membrane and form a negative layer within. This arrangement is known as an "electrical double layer," and the cell or fibre is said to be "polarized." (See Fig. 16.)

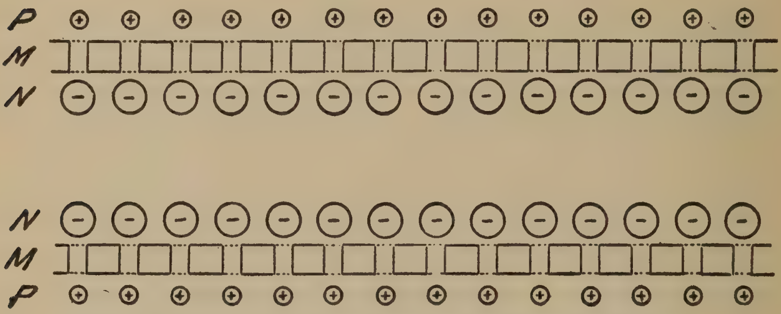

FIG. 16. DIAGRAM OF A NERVE FIBRE IN THE UNEXCITED STATE.

This is a symbolic section of a nerve fibre, showing the polarization layer. M represents the porous membrane, N the layer of large negative ions, and P the outer layer of smaller positive ions, which can pass through the holes in the membrane.

If such a state of polarization actually exists at the surface of a nerve fibre, it should be possible to demonstrate it by means of an electrical measuring instrument such as the galvanometer. It is a fact that if one end of a wire is inserted into the substance of a nerve and the other end is connected to the outside, an electrical current flows through the wire. The fibre acts like an electrical battery. This current is called "the current of rest" because it exists when the fibre is in the resting or unexcited condition. Its existence may be regarded as proof that the state of polarization which we have described is a reality. It may seem strange that the fibre should be thus electrified when it is in the so-called inactive condition, but it must be recalled that a living cell is never wholly inactive. If the cell were to die the current of rest would disappear as a consequence of the disintegration of the membrane.

"Depolarization"

The next question which we must consider is as to what happens when the nerve fibre cell is stimulated, so that a nerve current passes along it. One way of seeking an answer to this question is to find out by experiment what happens to the " current of rest " when the nerve current goes by. The test shows that, paradoxically enough, the effect is a marked *reduction* in the strength of the former. This reduction is known as the "negative variation," and sometimes as the "action current." Now there are apparently only two ways in which we can account for this depression of the current of rest during excitation. Either some of the protons on the outside of the fibre retire again to the inside, or else some of the negative carbonate ions temporarily escape from the cell.

The latter explanation is evidently the more plausible one since these negative ions are constantly bombarding the membrane from the inside, as if endeavoring to obtain exit. If they succeed in getting out during the excited state this may be due to an increase in the force of their bombardment, or on the other hand to an increase in porosity of the membrane. If we were to accept the first explanation we would be compelled to assume that the heat energy or temperature of the cell suffered a temporary increase, and the most delicate measurements show that there is no effect of this kind whatsoever. We must therefore suppose that excitation or the passage of a nerve current is attended by an increase in the *sizes of the openings* which exist between the molecules composing the membrane. This augmentation of the *porosity* of the membrane, so that large as well as small particles can pass through it with some ease is one of the essential features of the state of excitation. Another essential feature is the accompanying decrease in the polarization: a depolarization. (See Fig. 17.)

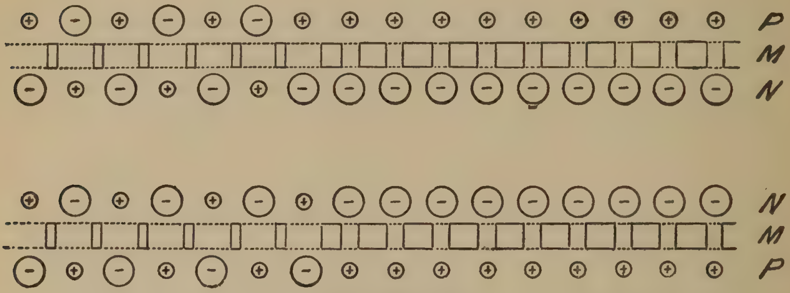

FIG. 17. DIAGRAM OF A NERVE FIBRE IN THE EXCITED STATE.

The general principles of this diagram are the same as those explained in Fig. 16. However, at the left-hand side the fibre is represented as being in the excited condition, the holes in the membrane being enlarged so that the negative particles can pass through, thus neutralizing the polarization layer in this region. (See Text).

Excitation and Conduction

If we accept the above account, the excitation of a nerve and the passage of a nerve current must be conceived somewhat as follows. The action of the stimulus first tends to make the membrane more porous at the point at which the stimulus is applied. This causes a local reduction of the polarization, due to the escape of the negative ions. These conditions now spread rapidly along the fibre, immediately adjacent points being affected first, and these pass the disturbance on to further points, until it finally reaches the opposite end. Thus, the state of the fibre at any point through which the current is passing is the same as that at the point of initial excitation. The current is produced because nerve substance in excitation becomes a stimulus to the excitation of adjacent nerve substance. This action has often been compared with the spread of fire along a train of gun-powder or other inflammable material. The speed of the nerve impulse is about three hundred feet a second in human nerves.

It would be interesting to have a more detailed explanation of the manner in which the state of increased porosity and decreased polarization spreads along the membrane. This explanation is suggested by certain facts regarding the conditions under which nerves are excited by the electric current. It has long been known that electricity is a very effective stimulus for all kinds of nerves. When an electric current acts upon a nerve it necessarily enters at one point and leaves at another. If we regard the electric current in a wire as a stream of electrons, the end of the wire at which the current enters will be negative, while that at which it leaves will be positive. The nerve is being sprayed with electrons at the negative end and electrons are being sucked out of the nerve at the positive end. A moment's thought will show that the polarization of the nerve membrane will tend to be increased at the positive end and decreased at the negative end of the wire. This is because the removal of electrons from the former location intensifies the layer of positive ions on the outside of the membrane, while the addition of electrons in the latter location at least partially neutralizes this layer.

Now we have already associated the neutralization of the positive layer with the act of excitation. Neutralizing this layer is equivalent to depolarization, for it makes little difference whether the negative particles come from the inside of the fibre (carbonate ions) or from the outside (electrons). Hence we might anticipate that the nerve would be excited by the electric current at the negative end of the wire, and experiment shows that this is the case. It is found, however, that this excitation is only *temporary*, since it occurs when the current is first turned on, but is not sustained with continued current flow. This leads us to believe that the nerve finds some way of overcoming the neutralizing action of the electric current. The most plausible way of accounting for this effect is the following.

The original polarization, or electrical double layer which encloses the membrane during the state of rest is due to the sifting action of the membrane upon the positive and negative ions. This allows the positive ions to pass through more readily than do the negative ones. However, we may suppose that a considerable number of the latter find their way through the membrane, so that the polarization is not as strong as it might conceivably be. This makes it possible for the membrane to increase its polarizing action by confining the negative ions more effectively. It can presumably accomplish this by packing its constituent molecules together more closely than ordinarily, a condition which is the exact opposite of that which is produced during the state of excitation, in which the packing becomes looser. We may therefore suppose that the continuous action of the electric current at the negative end of the wire fails to produce a continuous nerve current because the membrane combats the current by decreasing its porosity below that which characterizes the normal resting condition.

This explanation is confirmed by numerous further observations. One of these consists in the fact that the nerve becomes excited at the positive end of the wire when the electric current is shut off. While the current is "on," the nerve at this point is subject to an action which tends to increase its polarization above normal. We may therefore expect it to react to this abnormal condition by a measured increase in porosity, which cuts down its own polarizing tendency. Thus a normal degree of polarization would be reëstablished, a portion of this being due to the outside electric current. If this current is suddenly cut off, the membrane will be "caught napping," so to speak, and its polarization will suddenly fall to a subnormal value. This should result in excitation, just as is the case when the electric current is suddenly applied at the negative end of the wire.

The Basis of "Excitability"

The facts concerning variations in the *excitability* of nerve fibres also have a bearing upon this principle of "compensation." Excitability is measured in terms of the weakest stimulus which will suffice to set the nerve into action. The stronger the stimulus which is required the lower is the excitability. Now experiment shows that when an electric current passes continuously through a nerve, the excitability increases at the negative end of the wire and decreases at the positive end. This must be due to some change in the structure of the nerve substance at these two points. It is natural to suppose that this change is identical with the adjustments in porosity which we have just considered. If this interpretation is accepted, it follows that *decreased porosity means increased excitability* and *vice versa*. This is because the porosity has been supposed to increase at the positive end of the wire, where experiment shows that the excitability decreases, while opposite conditions are assigned to the negative end of the wire.

Such linkage of degree of porosity with excitability or its opposite is further suggested by the condition which is known as "*refractory phase*." This is the state which the nerve fibre assumes immediately after it has been excited. The state is called "refractory" because further excitation is impossible, regardless of the intensity of the stimulus which may be applied. Now we have assumed that the condition of excitation involves a marked increase in the porosity of the membrane, and hence the refractory state should be expected if increased porosity means decreased excitability. Another way of looking at the matter is to say that if the nerve fibre is already excited, it cannot respond to a stimulus because it is already responding. The situation is like that in which we ask a man to walk when he is already walking. However, we might reasonably command him to continue walking, but the analogous thing cannot be done to a nerve in the refractory state. It is deaf to all commands.

When a nerve recovers from the refractory condition it regains its excitability gradually. Of course the process is actually very rapid, occupying only a small fraction of a second, but experiment is nevertheless capable of showing that the excitability begins at a very low value and rises continuously. It is a striking fact that this rise does not cease when the normal excitability has been reestablished. There is an *overshooting*, which reaches a certain point and then gradually subsides again. During the period of recovery the membrane must be becoming constantly less porous. It finally reaches the normal condition of porosity, and passes through this in the overshooting phase into a state of porosity less than normal.

(See Fig. 18.) The change in porousness is one of the essential features of the excited condition and consequently the restoration of the original structure is required for the disappearance of excitation. It is evident that a nerve fibre is excit*able* in inverse proportion to the degree in which it is excit*ed*. To be excited it must be porous, but to be excitable it must be non-porous, or relatively so.

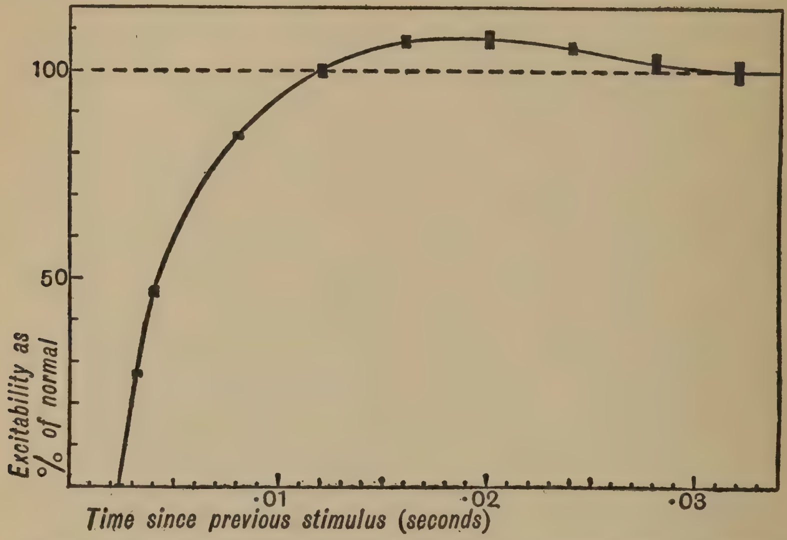

FIG. 18. CURVE OF RECOVERY OF EXCITABILITY OF NERVE AFTER A PREVIOUS STIMULUS. (This figure is reproduced from Bayliss, Principles of General Physiology, 1915, p. 389.)

The curve shows that immediately after stimulation the excitability is reduced to zero, after which it recovers gradually, reaching the normal condition in about one-eightieth of a second. This is followed by a period of temporary excess excitability.

The Mechanism of Conduction

We may now return to consider the manner in which the nerve current is passed on from one point to another of the nerve. We have seen above that a nerve can be excited by the action of an electric current which tends to destroy its polarization. This must mean that reduction of the polarization is followed by an increase in the porosity of the membrane. Otherwise there would be no complete state of excitation. But we have already seen that an increase in the porosity must necessarily be followed by a decrease in the polarization. Hence we must conclude that these two features of the nerve process are mutually dependent. If either of them is altered, the other will follow.

The passing on of the nerve excitation from one point to another of the fibre can therefore be explained as follows. Let us suppose that the stimulus acts to *increase the porosity*, as its first effect. This will be succeeded at the same point on the fibre by a *decrease in the local polarization.* However, this depolarizing effect will not be limited strictly to the region which is initially affected by the stimulus. The excited region is similar to a hole in the membrane, and the negative carbonate ions escape freely through this hole. They not only neutralize the positive ions which are directly over the hole, but they spread away from the edges of the latter and neutralize a ring of ions around the border of the hole. This border ring is thus depolarized and its porosity therefore increases. It is a rapid repetition of this series of actions which causes the excitation to travel along the fibre.

The Basis of the Excitation Threshold

There are several points with regard to the above general theory which require further explanation. One of these has to do with the manner in which the porosity of the membrane depends upon the polarization. The relationship between these two factors is apparently determined by the *speed* at which the polarization is changed. If the change is rapid the porosity increases as the polarization decreases. If, on the other hand, the decrease of polarization — produced by the stimulus — is slow or small, the opposite effect is noted. The polarization decrease causes a decrease in porosity. This is the compensation effect which we have already discussed. In general, the membrane resists a depolarizing force by decreasing its porosity and sifting the ions more rigorously. However, if the force is sufficiently strong to produce a certain critical degree of depolarization, this resistance breaks down and excitation ensues. If the force acts slowly, the membrane is able wholly or partially to maintain its normal polarization, so that this critical decrease does not result. If the same force were applied more suddenly, it might yield excitation.

Just as soon as the point is passed where depolarization begins to bring about an increase in porosity, a condition of unstable equilibrium is produced. The first downward move of the porosity is followed by a further depolarization which is a natural consequence of the porosity increase. This results in more porosity increase and so on, until the membrane has broken up to the maximum possible extent. The mechanism thus described may be compared to that which is involved in pushing over a chair by the back, using the finger tips without grasping the chair or restraining its motion. Up to a certain point the chair tips forward on the front legs and pushes back against the fingers. If the fingers are removed it falls back to its normal position, although in so doing it may overshoot — like the nerve — and tip backwards somewhat. However, if we continue to push the chair forwards, a point is reached at which it leaves the finger tips and crashes to the floor. This corresponds to the critical point or critical rate of depolarization mentioned above in connection with the nerve.

In order to make the comparison between the chair and the nerve exact, we may imagine that the chair tends to fall to the floor not because of gravity but because of the pull of a spring, which is variable. Furthermore, we must introduce a device which winds up or tightens this spring when any force is applied which might overturn the chair. Unless the chair has been tipped beyond the critical point, the increased application of the spring will act to hold it in the upright position. This effect is similar to that of the abnormally low porosity which is developed by the membrane in opposition to the stimulus. However, if the force which acts upon the chair is sufficient to carry it beyond the critical point, the increased action of the spring will cause it to strike the floor more quickly and with greater energy than normal. A similar effect is observed in the case of the nerve. The action current or negative variation of a nerve having more than normal excitability is in excess of the normal current or variation. Similarly, when the nerve is less excitable than usual the action current is also depressed.

The critical point to which the depolarization of the nerve must be brought in order to produce excitation is known as the *threshold*. The stimulus, so to speak, must step over this threshold before excitation can occur. The threshold is usually measured in terms of the smallest quantity of energy which will suffice to set the nerve off. The excitability is ordinarily taken as the "reciprocal" of the threshold, which is computed by dividing unity by the threshold measure. The principle of the threshold is of fundamental importance in the understanding of nerve action. It means that unless the intensity of a stimulus exceeds a certain critical value, there is no effective response of the nerve whatsoever. Different nerves have different thresholds, and the threshold of a single nerve varies from one time to another, under conditions which alter its excitability. Hence a stimulus which will excite one nerve may have no observable effect upon another, or its ability to set off any given nerve will depend upon the exact condition of the latter.

The "All-or-None" Law

The principle of the threshold has a companion which is known as the "all-or-none" law. This law states that if the threshold is passed the resulting excitation has the same magnitude regardless of the intensity of the stimulus. In other words, the intensity of the stimulus does not count in nerve excitation except for the requirement that it should reach the threshold. Although many painstaking experiments have been necessary to demonstrate the all-or-none law in the laboratory, its necessity is easily seen in the general theory of nerve action which we have outlined above. When the membrane is pushed to the unstable point at which the porosity begins to increase under the action of the stimulus, the nerve becomes its own stimulus and the outside force contributes nothing further to the process. The membrane structure breaks down to its maximum natural extent, and then starts to build up again. The case is similar to that of the chair in our analogy. If the chair has toppled over it will inevitably strike the floor, and it cannot go any farther than this no matter how hard we push it.

Recognition of the "all-or-none" principle immediately raises the question as to how different values of the stimulus intensity are to be represented in the nerve current. Or, more generally, how can the nerve current be regarded as variable at all? We supposed that such variation is possible when we assumed that the current is controlled by the two factors, intensity and resistance. Moreover, we know that consciousness varies in correspondence with stimulus intensity. The degree of brightness of light falling upon the retina of the eye is represented in all of its gradations by the picture which results in our visual perception. If it is true that consciousness is determined by the nerve processes in the cerebral cortex, the intensity of these processes must be regulated by those which are set off in the retina, in order that such representation should be possible. These facts seem to be inconsistent with the "all-or-none" principle.

The Basis of Variations in Nerve Currents

In attempting to solve this mystery we must consider first the fact that nerve activity as we have thus far described it is only a momentary affair. It is a "pulse" or an "impulse." Just as soon as the nerve fibre is excited it goes into the refractory state in which it is no longer excitable. Even if the stimulus continues to act, it is ineffective. The fibre starts to recover from the excited and refractory state, and only when the excitability has reached a proper magnitude is it ready to be stimulated again. When this point is reached a second excitation is set off and the cycle is repeated. The result is a series of impulses which travel along the nerve fibre as separated waves of activity. Any so-called continuous nerve current consists of a continued series of such impulses. Hence the nerve current more closely resembles the so-called "alternating current" of electricity than the "direct current" which has an uninterrupted flow.

When we think of the nerve current in this manner we see that it is only the magnitude of the individual pulses of excitation which is determined by the all-or-none principle. This principle says nothing concerning the *number* of these pulses which will be generated in a given time. However, the average amount of excitation arriving at the cortex will depend upon the number as well as the magnitude of the pulses. It is easy to show how the intensity of the stimulus acting through a sense organ of appropriate structure can regulate the number or frequency of the pulses. Hence the difficulty of transmitting a record of intensity from sense organ to brain disappears. The variable factor in the nerve current is the frequency. However, we must also recognize that the magnitude of the individual pulse is only constant for the same nerve in the same condition. Different nerves deliver different amounts of excitation to the cortex even when their currents are of the same frequency.

Another way in which nerve currents can vary in magnitude is offered by the large number of fibres which run parallel to one another and connect approximately the same points. If only a few of these parallel fibres are excited the effect produced upon the cortex will be less than as if a larger number were in action. In other words, the number of pulses arriving at the cortex will depend not only upon the frequency along any individual fibres, but upon the number of similar fibres which are simultaneously delivering currents. In some cases, as in vision with the center of the retina, a single fibre is called upon to transmit all possible intensity gradations, but in the majority of cases a considerable number of fibres coöperate in the performance of a single function.

In addition to registering the intensity of a stimulus, the sensory nerves must also report its *quality*, or general nature, to the brain. For example, there must be a differentiation between such things as light, sound and temperature. Of course, the characteristics of light or sound are not themselves transmitted to the brain, but the effects which are produced upon the brain must be different for different kinds of stimuli. In the majority of cases, this differentiation between the various kinds of agencies which affect the nervous system is accomplished by the sense organ. The several sense organs are respectively sensitive to special forms of energy. The eye responds to light but not to sound, the temperature nerves to certain degrees of heat but not to pressure, and so on. The sense organ can in fact be regarded as a *stimulus selector*, although at the same time it is a *stimulus amplifier*. But it amplifies only the special kind of stimulus which it is tuned to receive, and suppresses the action of other stimuli. In this way the sense organ arranges the matter so that under ordinary conditions each different species of stimulus excites a particular group of nerves; and the brain identifies the nature of the stimulus by the special nerve channel along which it arrives. However, there are some instances in which we are still doubtful as to whether this is the whole story.

The Physics of Synaptic Resistance

Our principal purpose in the above discussion of nerve physiology has been to throw light upon the physical nature of those cortical activities with which consciousness is directly correlated. As we have seen in earlier chapters, consciousness seems to be determined mainly by the cortical *synapses*. Now a synapse is primarily nothing but a place of contact or junction of two nerve fibres. Hence we should expect that the action which occurs at the synapse would be similar in general nature to that which takes place in the conducting nerve fibre. However, these general nerve characteristics may be specially modified to suit the peculiar duties which the synapse has to perform. The mechanism at the synapse may well be more complex than that which is involved in straightforward conduction. The various features of the nerve process may receive a different emphasis at the synapse from what they do in the rest of the fibre. For example, we know from our previous studies that the synapse is a region of high and variable resistance, while the resistance of the conducting nerve is low and practically constant.

When we examine into the physical nature of synaptic resistance, we find that it reduces to a question of *excitability*. Operating upon the all-or-none principle, the synapse either passes the individual nerve current pulse completely or not at all. High resistance means a high threshold and low excitability. Hence, when the resistance of a synapse increases this is due to a decrease in its excitability. That a state of depressed excitability should exist in the region of nerve contacts can be inferred from the general principles of nerve action which we have considered above. Since both of the nerve ends are coated with positive ions, they act upon each other just as the positive end of an electric circuit acts upon a nerve. They tend to reinforce each other's polarizations. As a consequence of this, the membranes of both nerves will compensate by increasing their porosity, and this — it will be recalled — means a decrease in excitability. Thus, when a nerve impulse strikes a synapse, it is in danger of finding itself unable to step over the very high threshold which the synapse presents to it.

Another characteristic of the synapse, as compared with the remainder of the nerve fibre, lies in the slowness of its processes. It is particularly slow in recovering from the after-effects of excitation. Here we find a clew to the mechanism by which exercise and the cortical encouragers are able to decrease the resistance of a synapse. We have noted that after a nerve fibre has been excited, it overdoes the process of recovery and overshoots into a condition of abnormal excitability. Such excess excitability corresponds to a decrease of resistance in the case of a synapse. We have only to suppose that the overshooting effect lasts a long time in a synapse, and that such effects accumulate from one excitation to another. The gradual recovery from this condition of increased excitability would correspond to the lapse of synaptic records through disuse.

There is evidence that some synapses have a special structure which is presumably different from that of the remainder of the nerve fibres of which they form parts. This evidence appears in the demonstration that a nerve current arriving along certain fibres can act as a synapse so as to *block the passage* of currents coming from other fibres. Synapses seem to be of two general kinds, positive and negative. The former have an exciting and the latter an "inhibiting" activity. This difference can be explained by supposing that the molecules and possibly the ions which are involved in the two types of synapses are different in kind or arrangement or both. One possibility is that the "polarization" of an inhibiting synapse is opposite in direction to that of an exciting one. By this we mean that negative ions are on the outside of the cell in place of the positive ions. The action upon the cerebral cortex of the sensory nerves which we have called "discouragers" may be conceived to occur at least in part through such inhibitory synapses.

It is highly probable that the billions of synapses which exist in the cerebral cortex possess a wide variety of structure and many variations in process. This is suggested by anatomical differences which are observable between various portions of the cortex, and is borne out by the wide variety of experiences which these cortical activities underlie. It is a general principle of the relation of consciousness to matter that for every distinction which can be made on the mental side there must be a corresponding one upon the physical side. If we accept the proposition of previous chapters that consciousness is directly determined by the structures and activities of the cerebral cortex, we must suppose that the cortical matter conforms to a pattern from which the nature of consciousness can be deduced. The problem of the next chapter will be to consider more intimately this fascinating question of the direct relationship between consciousness and matter.

CHAPTER XIII

THE FUNDAMENTAL RELATIONS OF CONSCIOUSNESS AND ELECTRICITY

WE have seen in the preceding chapter that nerve activity is an electrical process which at the same time involves changes in material structures. In the resting state the surface of a nerve fibre is coated with positive ions, while underneath its surface there is a layer of negative ions. Between these sheets of ions there is stretched a field of electrical force which binds them together. The membrane which also lies between them is subject to the action of this electrical force field. Although we may describe the membrane as being composed of unelectrified matter, we must not forget that fundamentally all matter is made of electrical particles. Such particles are always acted upon by fields of electrical force. Consequently the condition of the matter which composes the membrane will be modified by the presence of the force field. This is undoubtedly the reason why its porosity is influenced by changes in the intensity of the field, resulting, for example, from the action of an external electric current.

When a stimulus appears and the nerve is excited, the force field and the structure of the membrane alter together. Electrified particles pass through the membrane and escape from the cell. Other particles, including oxygen molecules and food materials, pass into the cell. When this occurs a source of internal energy becomes operative and starts a process which eventually restores the membrane substantially to its original condition. We feel quite sure that this energy is derived from a chemical combination of oxygen with food substances in the cell, since deprivation of oxygen makes the cell incapable of recovery. All of these changes can take place in a very small fraction of a second and can be repeated many times a second.

The Unity of the Nerve Process

Either in the resting or the excited condition, the nerve membrane and its polarization layer can be regarded as forming a unified whole. It is a system of electrical particles which are connected with one another by fields or lines of electrical force. These lines not only pass between the ions which form the polarization layers, but they also link the ions with the particles which compose the membrane. These membrane particles are also united very strongly by the electrical forces which underlie their chemical and physical coherence. There must be a unification parallel to the membrane as well as perpendicular to it. The boundary of the nerve forms a sheet of electrically coherent units, and when a change occurs at any point in such a structure it tends to spread to adjacent points. The binding together of the particles makes them mutually dependent and causes them to act in unison.

However, such unification of the nerve structure has its limits, which are imposed by distance and by time. The particles at one end of a nerve are much more closely bound to their immediate neighbors than they are to those at the opposite end. Adjacent particles are subject to the excitation process simultaneously, but there is a considerable lag of excitation at the far end of a stimulated nerve. This lag is expressed in the principle that it takes a definite time for the nerve impulse to travel from one point in the nerve to another. The lag may be such that the region of a nerve which was first stimulated has completely recovered from the excitation while some other portion is excited to the greatest degree. We must suppose that two portions of a single nerve which are simultaneously undergoing opposed changes are not well unified. This would be true of regions which are entering and leaving the excited state, respectively.

On the other hand, the unification of the nerve activity is not necessarily limited to a single nerve fibre or cell. The lines of electrical force stretch from one fibre to another at a synapse. If such were not the case, it would be impossible for the excitation to be passed on at such points. This is true, of course, only of synapses which have a sufficiently low resistance actually to permit the transfer of excitation. The lower the resistance of a synapse the greater the unification which it will make possible between the nerve units which it joins together. Nerve elements or activities may be considered as unified when they are adjacent and undergo similar changes at the same or nearly the same time. They are unified in proportion as lines of force bind together their component particles. In such a system of closely connected nerves as the cerebral cortex, a vast number of individual nerve cells may be combined into an organic whole in this way.

The principle of unity or of unification which we have thus applied to the nervous system is fundamentally the same as that which holds for all material structures or activities. We have already seen in our review of modern physics that the physical world is made up exclusively of electrical particles and that all of the forces in this world are variations or combinations of the electrical fields with which these particles are endowed. However, the nerve membrane is somewhat unique in that the fields of force in the polarization layer are spread out or *open*, whereas in the majority of structures they are less diffuse or are more tightly *closed*. A closed field

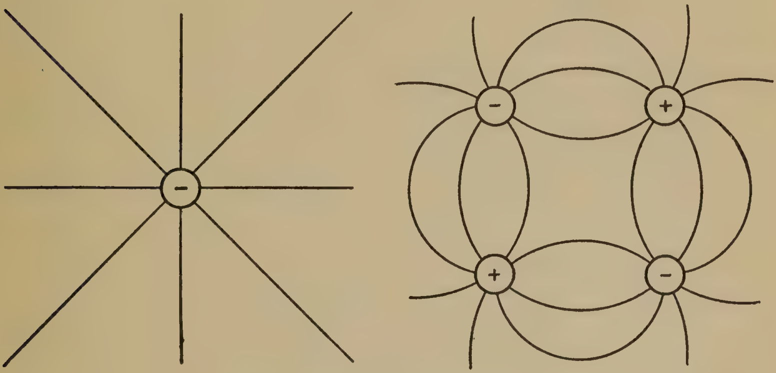

FIG. 19. ELECTRICAL FORCE FIELDS.

The diagram on the left shows a single negative charge of electricity, having a completely "open" force field. The diagram on the right represents a combination of two negative and two positive charges, with a relatively "closed" field.

unites the particles which it joins, but the unification is not comprehensive. It is restricted to a few units which form a small and relatively isolated combination. Where the corresponding positive and negative particles are more widely separated, as in the nerve surface, a larger and more complex whole can be formed. (See Fig. 19.)

The Structural Relations of Consciousness and Cortex

Our analysis of consciousness in an earlier chapter has shown us that — like the nerve activity in the cortex — it is at once unified and complex. At any instant, consciousness consists of a large number of different sensations, feelings, etc., and yet all of these factors are combined so as to form a coherent whole. Our study of the interdependency of consciousness and matter led us to believe that each man's consciousness is associated directly with activities occurring in his cerebral cortex. Although the consciousness usually mirrors some condition of the outside world or of the body in general, its relation to these things which are outside of the brain is only indirect. They influence the cortex through the sensory nerve channels, but it is the cortex alone which determines the nature of consciousness.

Our belief that consciousness is determined by cortical activities rests upon a sound experimental basis. However, even if there were no definite facts bearing directly upon the question, we should be led to select the cortex as the physical basis of consciousness merely from a consideration of its anatomical structure and relationships. We have seen that all of the sensory nerve currents converge upon the cortex. Likewise, the nerves which control the voluntary muscles diverge from the cortex. Within the cortex are laid down the records of habit and memory, together with the system of complexes which furnished the basis of personality. However, the cortex is a large and extremely complicated organ, and we can feel quite certain that only a relatively small portion of it is involved in any single moment of consciousness. We therefore face the question as to the exact location of the processes which are concerned, as well as that of their intimate nature.

In endeavoring to find plausible answers to these questions we shall be greatly helped by certain general principles which have already been vaguely suggested. We have recognized the fact that consciousness and the brain are two entirely *separate* things. They are also radically *different* things, in the sense that they are essentially dissimilar in substance and special form. Consciousness is made up of sensation, image, feeling, and so on, while the brain is an arrangement of protons and electrons which are held together by electrical forces. Space as found in consciousness differs greatly from space as described by the physicist. Nevertheless, these considerations are not inconsistent with the existence of certain general similarities between consciousness and that portion of the brain apparatus which directly determines consciousness. For example, as just indicated, they can both be complex and yet coherent or unified. Unless we assume the reality of such general similarities, we are rather at a loss in any attempt to specify the nature of the nerve structures or processes which must underlie consciousness.

We must suppose in the first place that the physical mechanism in the cortex which is responsible for consciousness must be at least as *complex* as the latter is itself. For every part of consciousness there must be a *corresponding* part of the cortical system. A similar correspondence must exist for features of consciousness other than parts, such as aspects, attributes, changes, etc. A second general proposition is that when two features of consciousness are different in nature or activity, the corresponding features of the cortical mechanism must also be different in kind. If two factors of consciousness are similar, the corresponding physical factors must likewise be similar. A third general principle is that if two portions of consciousness are closely related the corresponding parts of the cortical system must also be intimately associated. The broadest application of this principle lies in the proposition that since all parts of consciousness are grouped together into a coherent whole, the same must be true of all those constituents of the cortex which underlie this consciousness.

All of these principles can be combined into the general statement that consciousness and the brain mechanism which underlies it have a similar logical *formula*. As an example of the meaning of this statement we may consider the case of a motion picture and a novel, both of which portray the same story. The medium and the material form of the picture are radically different from those of the novel, and yet they have the same plot, or the same meaning. A large office building and a wooden block are very different things, and yet they may be similar in that both are rectangular. A piece of music as played by a pianist and the score which he has before him are radically different things, and yet they have a corresponding structure. How this kind of relationship works out for the case of consciousness and the cortex will become clearer as we proceed.

Elements of Consciousness and Cortex

The problem of the direct relationship between consciousness and the cortical mechanism presents several separable aspects, in harmony with the above statements. In the first place there is the problem of the *elements* of consciousness and of the cortical process respectively, and their interrelations. By elements we mean the simplest and smallest parts of the systems in question. Thus, in the case of consciousness, a minute red spot or a pin-prick pain can be regarded as an element. Something must exist or happen in the cortex which *corresponds* to the red speck. Something *different* must exist there to correspond with the pain point. The same propositions apply to any other constituent of consciousness. One way of forming a concrete conception of the nature of this problem is to consider what must happen when an element of consciousness is subject to *change*. For example, let us consider that the red point fades gradually and continuously through a series of pinks or light reds into a white. While this is occurring, the cortical element or part which corresponds to the point must pass through a continuous series of gradations, corresponding to the several pinks or light reds and ending with a modification which corresponds with white.

The most important elements of consciousness are those which we have called the sensations. It will be recalled that the sensations were divided into the external and the internal. The external sensations include those of sight (visual), hearing (auditory), smell (olfactory), taste (gustatory), and touch (tactual), the classical five senses. Each of these separate fields of sensation embraces a considerable number of different elements.

The Case for the Visual Elements

In the case of vision, there are the six principal colors — red, yellow, green, blue, black and white — together with an almost innumerable system of gradations between them. All of these colors, including the gradations, are represented by the so-called *psychological color solid.* This system of colors shows that its members possess three general characteristics, which are known as hue, brilliance and saturation. The hue stands for the reddishness, yellowishness, bluishness, or greenishness of the color, as the case may be. The brilliance stands for the degree in which the color differs from black or complete darkness, while the saturation stands for the degree in which it departs from a gray of the same brilliance as itself. The nature or psychological quality of any color can be completely specified in terms of these three characteristics. (See Fig. 20.)

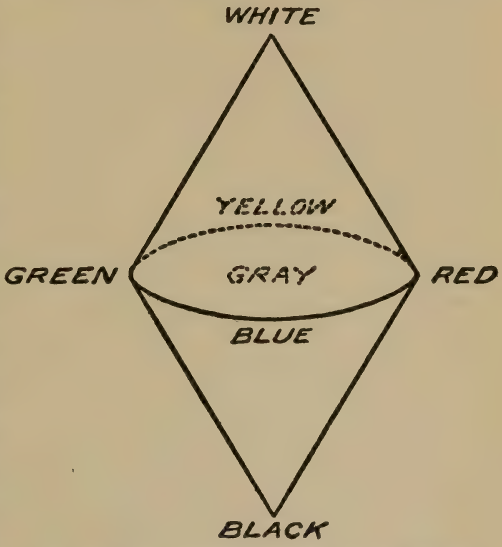

FIG. 20. THE PSYCHOLOGICAL COLOR SYSTEM.

The diagram represents the possible dimensions or attributes of colors, regarded as sensations. All colors are characterized by the possession of hue, brilliance and saturation, and all possible colors can be given characteristic positions in the space which is represented by the diagram.

By way of illustration, let us consider how the problem of the relation of the elements of consciousness to those of the cortical process works out for the case of the colors. In general, we must suppose that there are as many possible and different cortical factors as there are different colors in the color solid. Moreover, it should be possible to arrange these cortical factors into a system exactly similar in form to the color solid. (This is a concrete instance of the identity of general logical formulae between the conscious and the cortical which we have mentioned above.) In this system of cortical factors there will be a characteristic corresponding to hue, another corresponding to brilliance, and still another corresponding to saturation. Hence our investigation of the problem may consist in inquiring as to the cortical basis of the three characteristics of all colors.

The problem is evidently a difficult one to solve. There is at present no available method of observing the living human cortex physically, except in surgical operations. Even in the latter cases we see nothing which helps us to solve our problem. Humanitarian considerations prevent us from attempting to dissect out individual fibres and synapses, and trying to measure their electrical properties. Indeed, even under these conditions we would have no experimental methods which would be adequate to the task. We are therefore compelled to have recourse to somewhat more theoretical and speculative methods of inquiry. In applying such methods we start with known facts and endeavor to infer the unknown facts.

One of the first groups of facts which we consider are those which have to do with the stimulus. In the case of vision, we readily find a system of stimuli which corresponds at least approximately with that of the sensations. There are special forms of radiant energy or "light" for each color. All of these forms of radiant energy can be arranged in a scheme having three characteristics which correspond fairly well with those of the color solid. Thus, for hue we find wave-length, for brilliance we have intensity (or energy), and for saturation there is "purity." Radiant energy, being a wave disturbance, can vary in the length of its waves, in their height (determining their intensity) and in the degree to which any given wave-length is singly represented. However, the correspondence between these features of the stimulus and the three characteristics of color is far from being perfect. Although hue varies with wave-length, this variation is not uniform in rate, being rapid at some wave-lengths and very slow in others. Some of the hues — viz., the purples — cannot be obtained from any single wave-length but require a combination of two, which must be varied in their intensity proportions. Another difficulty is that equal intensities do not yield the same brilliances for different wave-lengths. Moreover, saturation is not constant for various wave-lengths at the same degree of purity.

In order to explain these discrepancies, and also to advance a step nearer to our goal in the cortex, we must consider what happens in the retina of the eye. Here, unfortunately, most of our positive knowledge vanishes, and we are reduced to speculation. Nevertheless, our theories regarding the retinal process are not entirely lacking in a basis of fact. A careful study of the relationship between colors and radiant energy of various wave-lengths and compositions, shows that the color system is much simpler than the stimulus system. The majority of colors can be produced by more than one wave-length or combination of wave-lengths. Moreover, experiment shows that three single wave-lengths can be found which can be combined in various proportions to produce colors of all hues and of a wide variety of saturations, including white and grays. This leads to the view that the retina has three separate forms of excitability, each of which has a fixed color value. Other colors rest upon mixtures of these three activities in different proportions. These proportions are determined by the degrees to which the three activities are aroused by the given radiant energy stimulus.

Unfortunately the three excitabilities of the retina do not correspond to hue, brilliance and saturation, respectively. They are related, rather, to three "primary" colors: red, green and blue. Unfortunately, also, we do not know the physical nature of these excitabilities. However, it is usually supposed that they are three different chemical substances which are decomposed selectively by the action of radiant energy of the proper wave-lengths. This supposition is borne out by the fact that at least one substance of this kind has actually been extracted from the retina by chemical means. If we accept the theory we must then consider how these decomposing substances control the currents in the optic nerve fibres. Here our knowledge becomes even less satisfactory but still there are some statements which can be made with a degree of certainty.

The Nature of the Visual Nerve Currents

We can feel quite sure, in the first place, that the optic nerve currents are similar in general nature to those in other nerves, and hence that they consist of a series of pulses. Under ordinary conditions all of these pulses must be of the same magnitude, in harmony with the "all-or-none" principle. Consequently the only thing about them which can be altered is their *number* and their *spacing*. These characteristics must be capable of varying in at least three different or independent ways, since the reactions of the three substances in the retina must be telegraphed separately to the brain in order that their proportions may control the three characteristics of color in consciousness. However, it is not necessary that the natural way of subdividing the features of the nerve current should yield the exact aspects which correspond respectively to the three retinal reactions. For example, it is natural to regard the number or frequency of the nerve pulses as an individual feature of the nerve current. It is likely, however, that this feature corresponds to the sum of the activities of all of the retinal substances. On the other hand, it seems probable that this pulse frequency is individually responsible for the cortical process which underlies the *brilliance* of a color.

The most plausible view concerning the representation of the retinal reactions and of color characteristics in the optic nerve current seems to the writer to be as follows: When the three retinal substances are decomposing at equal or equivalent rates, the nerve current consists of evenly spaced pulses. If the rates of decomposition are all increased or decreased in proportion — so that their balance is not disturbed — the distances between the individual pulses change, but these distances still remain equal to one another. The higher the rates of decomposition the closer together the pulses will be. In other words, there are more pulses for more retinal activity. Other things remaining constant, there will be more pulses for more stimulus intensity. However, the number or frequency of the pulses will not be in simple proportion to the intensity but will vary with respect to the latter in the manner which mathematicians call "logarithmic," or with a constantly diminishing rate of increase as the intensity becomes greater. On the side of consciousness, this evenly spaced nerve current will yield the series of gray or hueless colors, ranging from black to white. Black will correspond to a current with very widely spaced pulses, while white will go with pulses which are crowded very closely together.

If the *balance* between the decompositions of the retinal substances is upset, the spacing of the pulses will become *irregular.* We must suppose that each of the three substances tends to introduce a peculiar rhythm of its own into the current. These rhythms are such that under the conditions of balance which we have considered above they cancel one another, or combine to produce a regular succession. The degree to which any substance preponderates over others is represented by the degree to which the regularity of the pulses is displaced in the direction of the peculiar rhythm of the given substance. The principle which is involved here is somewhat similar to that which is employed in the radio-telephone transmission from a modern broadcasting station. There is a fundamental train of waves upon which other wave forms are superposed. In radiotelephony this principle is known as that of *modulation*, and the same term may be used for the nerve current. It should be noted, however, that in radio the *intensity* of the fundamental wave train is modulated, whereas in our conception of the optic nerve current it is the fundamental *frequency* which is subject to modulation.

The particular *hue* which is exhibited by the color in consciousness will depend upon the exact *form of the modulation* rhythm which is impressed upon the nerve current. The shape of the rhythm, so to speak, determines the quality of the color. It is clear that although certain rhythm forms may stand out as being distinctive or individual, nevertheless various combinations of these fundamental forms will also have a qualitative individuality of their own. The series of rhythm forms will thus bear a close analogy to the series of hues. Some combinations of fundamental rhythms may be as distinctive as the fundamentals themselves. This may explain the distinctive character of the hue called yellow, which seems to rest upon a balanced decomposition of the "red" and "green" substances, in the relative absence of activity on the part of the "blue" substance. The third characteristic of color, its *saturation*, can be attributed to the degree to which the nerve current departs from the perfectly regular series of pulses, in the direction of any given rhythmic form. It is a *measure* of the rhythmicity, so to speak, without identifying the particular rhythm which is involved.

What Happens in the Visual Cortex

The above conceptions are undeniably speculative. Nevertheless they rest upon a large number of facts, and upon a careful study of the requirements which are set by these facts. Although they may not be valid exactly as stated they are probably of the right general nature and indicate the kind of ideas that we must employ in working out the fundamental relationships between nerve activities and consciousness. Hence we are justified in taking the next forward step along the nerve path, in order to consider what probably happens in those cortical synapses which are directly associated with the appearance or the existence of the color in consciousness.

On the way from the retina to the cortex, the optic nerve currents pass through several way-station groups of synapses. It is entirely conceivable that the characteristics of the nerve currents are changed in traversing these synaptic regions. It is well known that such modifications can be brought about by synapses. On the other hand, there seems to be no good reason why the optic nerve currents should alter essentially on their way from the retina to that portion of the cortex upon which they first impinge. Such alteration would only confuse the representation which the nature of the stimulus has already been given in these currents. Hence it is most reasonable to suppose that the same frequencies and rhythms which are impressed upon the nerve ends at the retina are transmitted substantially unaltered to the receiving points in the cortex.

However, it does not follow from this that the cortical activity in its entirety will be exactly like that which occurs at the retinal ends of the nerves. This is because, in the first place, the nerve substance in the cortex almost certainly differs in structure or constitution from that in the optic nerve. We can feel certain of this for the following reasons. One of the most fundamental duties or functions of the cortex is *discrimination.* This means that it must be so constituted that it reacts *differently* to different frequencies, rhythms, and arrangements of the nerve currents or impulses. Such differences of reaction are evidently necessary in order that the outgoing (motor) nerve currents — and thus the behavior of the individual — should be regulated in accordance with the incoming nerve currents.

In our preliminary discussion of this regulation we have treated it as if it were all a matter of single connections between individual nerve fibres. However, no very profound thinking is required in order to demonstrate that the mechanism must be far more complex than is indicated by this simple scheme. We can respond to a red light — as a danger warning — in the same manner regardless of its size, shape, motion or position upon the retinal field. We can also respond in a constant manner to a given figure or shape, such as that of a human being, regardless of size, color, position, etc. In order to deal with identical nerve fibres having fixed connections like an electrical circuit it would be necessary that a given object or stimulus should always operate through the same group of nerve fibres upon the sensory side. This requirement is evidently not satisfied.

How are we to explain the manner in which the cortex differentiates between nerve currents on the basis of general features such as shape and quality? One way of doing this is to start with the supposition that each particular form of behavior or outgoing nerve activity is associated at some point in the brain with an exclusive set of nerve elements (such as synapses). This set of elements must operate somewhat on the principle of a radio set which is tuned to a particular wave-length. The radio receiver will pick up the given wave-length regardless of the path by which it reaches the vicinity of the receiver. The only thing which counts is the inherent nature or quality of the specially selected wave. The wave must be electromagnetic and it must lie within a certain band of wave-lengths. The receiver shows an ability to *discriminate* between different waves and to select a particular one as the basis for its behavior. This ability is due to the inherent structure and setting of the receiver: its special "tuning." We may consider this same principle of tuning in a somewhat more general form, to apply to the mechanism in the cortex. There are nerve arrangements in the cortex which are tuned to "red" regardless of accompanying features of the incoming nerve currents. There are other nerve formations which pick up the human figure, regardless of size, position, or color; and so on.

The ability of any particular nerve arrangement of this sort to select its proper kind of nerve current must depend upon *a special structure or constitution.* Hence nerve formations which pick up different kinds of nerve currents must have different constitutions. It follows that when the incoming currents arrive at the cortex they must be distributed to separate and different cortical components. These components may frequently be in very close proximity but they are nevertheless distinct structural parts. In the visual case which we have been considering, the rhythm in the nerve current which stands for red will be sifted into the "red" receiver in the cortex, while the rhythm for blue will go to the "blue" receiver, and so on. Now the total nature of the process in the cortex which corresponds to the red sensation will involve the inherent nature of the "red receiver" as well as the special rhythm which represents red in the nerve current. Hence we must suppose that there is a special material or electrical structure underlying red as well as a special activity or change. Thus the "red excitation" in the cortex, regarded as a whole, is a combination of structural and the dynamical (or change) features. *It is a certain structure undergoing a certain change.*

Our analysis of color as a factor in consciousness has shown that there are six distinctive colors, red, yellow, green, blue, black and white. However, when these colors together with the gradations between them, are combined into a system (the color solid) there are only three ways in which color can vary independently. These are the ways called hue, brilliance and saturation. We also found that there are apparently only three independent ways in which the retinal activity and the optic nerve currents can vary. Hence we are tempted to refer the *six*-fold analysis of colors to the selective or "pick-up" structures in the cortex. Thus, there would be a special cortical receiver for red, another for yellow, another for green, etc. The red receiver responds to the nerve rhythm which is sent out by the "red sensitive" substance in the retina, the "yellow receiver" reacts to the equal proportions of "red" and "green" rhythms, etc.

The white receiver is excited in proportion as the nerve current is non-rhythmic, and the black receiver functions in proportion to the inactivity of the white receiver.

The Relation of Quality to Physical Structure

There are of course many other possibilities for the explanation of the variety of color elements which we find in the visual consciousness. The above discussion is presented mainly with the purpose of providing as concrete an illustration as possible of the kind of doctrines which we must develop in dealing with fundamental relation between consciousness and matter. The general principles which come out of this illustration may be summarized as follows. Consciousness contains a tremendous variety of qualitatively different elements. The physical world has only two ultimately different elements: the electron and the proton. Hence the various elements of consciousness must rest upon different *forms of combination* of electrons and protons, together with *different changes or processes* which such combinations undergo. A variation of structure or of process in the cortex may thus be represented by a variation in quality in consciousness. The ultimate laws which associate the nature of conscious elements with the corresponding material (or electrical) factors in the brain are laws which link *quality* on the one hand, with structure and change on the other hand. If we knew these laws we could deduce the quality of the conscious element from a knowledge of the structure and process of the corresponding brain factors, or *vice versa.*

One seeming difficulty with this doctrine is the fact that the conscious factors, such as red, are apparently simple, while the corresponding physical factors are quite complex. This difficulty can readily be avoided by the following considerations. We may suppose in the first place that the physical method of analysis is a more powerful one than is the psychological (or introspective) analysis. Direct observation reveals no complexity in red, but the physicist applies ingenious instruments and methods of computation to such physical structures as the brain and arrives at deeper understanding of their constitution. A second point is that the physicist probably *overemphasizes the structural aspect* of the things which he studies. As we have already seen at the beginning of the present chapter, any combination of electrical particles is held together by fields of electrical force. These fields lie between the particles and are essentially smooth or continuous in nature, although they have a characteristic form which is determined by the positions of the particles. It is equally true, however, to say that the positions of the particles are determined by the form of the field. The field may be regarded as a unitary thing whose form corresponds directly with the quality which appears in consciousness. There is nothing evident in consciousness which corresponds to the electrical particles, although the physicist tends to regard these as rather more important than the fields.

The Physical Basis of Conscious Structure

Some electrical and magnetic fields are very powerful while others are extremely weak. In general, the greater the distance which separates the particles the weaker the intervening force fields will be. However, this weakening is simply in terms of the forces which are actually used in binding the given group of particles together. The strength of the fields in the immediate neighborhood of any particle remains the same as before. Thus the group loses in unity, while the particles do not. Hence we should expect that a consciousness corresponding to such an electrical structure would be less unitary and more easily analysable into parts, than one corresponding to a more compact group of particles. This is probably the key to the distinction between the elements and the structure of *consciousness* itself. As physical combinations become increasingly loose-jointed, a point is reached in the corresponding consciousness at which introspection is able to detect parts which correspond to separate constituents of the physical structure. These parts will be so-called elements of consciousness and will be clearly separable in proportion to the weakness of electrical union of the corresponding physical factors.

The structural aspect of consciousness appears very clearly in vision; less clearly, but still definitely, in audition. If we are looking at an American flag, the structure is simply that of the flag as we ordinarily think of it. It has white stars in a blue field, combined with white stripes alternating with red ones. The elements are the minute points of red, white and blue which make up this pattern. In the case of a musical chord, an untrained observer may detect no parts, but the trained musical ear is able to analyze the chord into component tones. Other departments of consciousness exhibit other degrees to which their structure can be made out and thus their parts distinguished. It is to be noted that even in the case of a consciousness which has an obvious structure there is a peculiar characteristic quality of the consciousness as a whole which is over and above the qualities of the components of the structure. This so-called "form quality" can be regarded as the result of a partial unification of the components, which is not sufficient to disguise the structural arrangement. In other words, there is always some degree of union in any consciousness and in so far as this union exists there is a development of new qualitative characteristics. Examples of consciousness or experiences which have an evident structure and which nevertheless have qualitative individuality are musical melodies, paintings, the tastes of complex foods, etc.

CHAPTER XIV

THE SUBCONSCIOUS MIND

Resumê

We have pictured consciousness as a mental reality which lies entirely outside of and beyond the physical brain. Yet at the same time we have represented it as having a very definite relationship to particular parts and activities of the brain. Consciousness seems to depend for its existence and nature upon these brain processes. In the preceding chapter we have endeavored to suggest the detailed form of this apparent dependency. The brain process and consciousness are both complex. They have definite structures in terms of certain characteristic elements or parts. The ultimate elements of the brain must be electrons and protons. Those of consciousness are sensations or similar units which are distinguished from one another by their differences in quality. A detailed correspondence is supposed to exist between the structure of consciousness and that of the brain process, so that in a very general way the two structures may be regarded as similar to each other. This similarity obviously cannot signify any degree of identity between them, because of the differences in fundamental nature between electricity and consciousness, and also because of the imperfection of the similarity.

Notwithstanding this imperfectness of the similarity between the brain process and consciousness, we believe that the latter is completely determined by the former. For every difference in the nature of consciousness there is a corresponding difference in the nature of the brain process. However, since there are so many more seemingly ultimate elements in consciousness than there are in the physical world, we must suppose that the qualitative differences between parts of consciousness usually correspond to structural differences between the ultimate parts of the brain. We account for the transition from structure to quality by noting that physical structures are not always so easy to break up into separate parts as they seem. From one point of view, every physical structure which is bound together by forces of electrical attraction, forms a unity. This unity resides in the smooth or continuous character of the electrical field between the particles (electrons and protons). When the physical structure is relatively large and loose there is less unity and the corresponding consciousness presents an obvious structural similarity to the brain mechanism.

The Central Brain Process

Now, consciousness as a whole — my consciousness or yours at any moment — is a unified thing. It combines many different kinds of sensations and many different combinations of sensations. It integrates sight, hearing, touch, smell, taste, feeling, etc., into a single and definitely bounded whole. Hence it is natural to suppose that there is a group of activities in the brain, corresponding to consciousness, which has a similar unity. This union of activities must combine the nerve currents which are received from the eyes, the ears, the skin and all other sense-organs. These currents must be modified in accordance with past impressions to correspond with the phenomena of perception, recognition, memory, etc. They must also receive additions due to the more or less spontaneous activity of the brain. All of these processes must be fundamentally electrical in nature, and their unification must therefore be through the positive electrical fields which interconnect them. Thus we arrive at the notion that consciousness as a whole is related to an electrically unified set of nerve activities in the brain which represents a flowing together of practically all of the incoming (sensory) currents. Let us call this the *central brain process*. (See Fig. 21)

It is to be noted that this central activity not only *pools the information which is gained from all of the senses, but it also forms the central control point for all of the voluntary muscles*. It is a kind of focus towards which the incoming currents converge, and from which the outgoing currents diverge. It operates like the chief executive of a business enterprise, binding together all available data from the outside world and the past, and then issuing orders for action in accordance with the requirements of these facts. This explains the value and necessity of the unification which the system is supposed to possess. In order that the deliverances of the different senses should be made the basis of a single coherent judgment and act, they must come into intimate contact with one another, so that

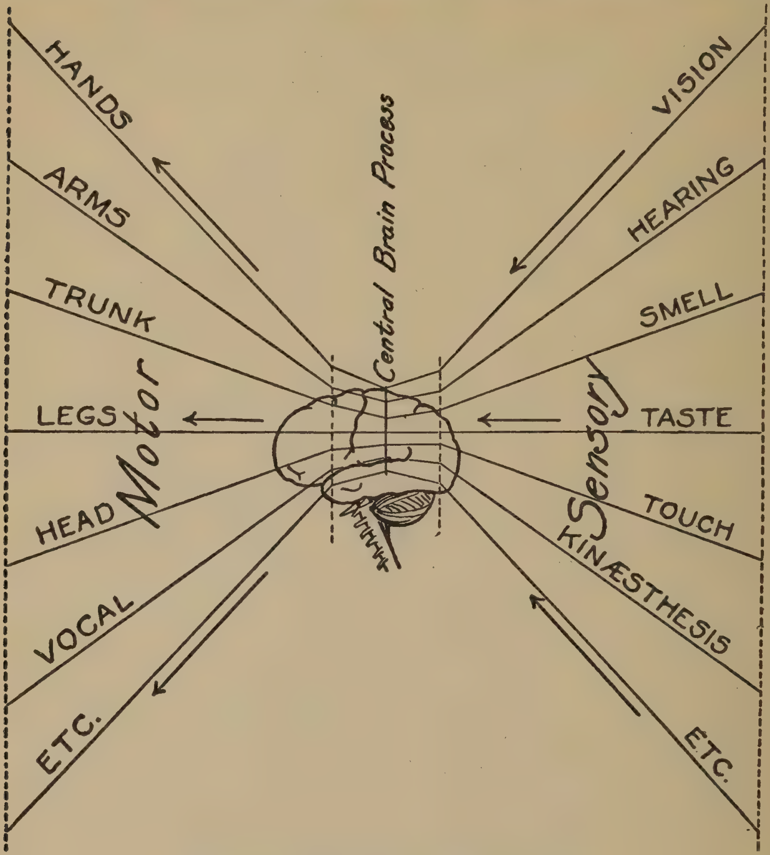

FIG. 21. THE CENTRAL BRAIN PROCESS.

This diagram symbolizes the relationship of the central association processes of the cerebral cortex to the incoming (sensory) and outgoing (motor) nerve currents. (See Text).

they can combine to produce a resultant nervous effect. They must also be combined with the records of the past, and the outcome must operate through the "purposes" or complexes of the individual to produce the required form of behavior.

The question evidently arises as to what is the exact position of this unified central nerve process in the brain. From what has already been said in previous chapters it is quite evident that it lies in the cerebral cortex. But the cerebral cortex is a very large organ, and it is quite improbable that the whole of this organ is involved in the central process at any single instant. We have already mentioned the fact that the cortex is divided up into areas which apparently have different duties to perform. There is one set of areas to which the sensory nerves are directly connected. They constitute the cortical receiving points for the incoming nerve currents. There is another group of (adjacent) areas which occupy a similar position with respect to the motor nerves. It is from these areas that the outgoing currents leave on their way to the muscles. However, these two classes of cortical areas are very far from covering the entire surface of the organ. The remaining regions are called "association areas" because they are connected by nerve fibres with both the motor and the sensory surfaces. Another reason for the name is that we believe that the nerve currents must pass through the association areas on their way from the sensory to the motor portions of the cortex.

The Location of the Central Process

We are tempted at first to suppose that the brain activities which underlie such a consciousness as a visual sensation or perception, are located in the special areas of the cortex to which the optic nerve currents pass directly. Similarly, we might look for the location of the activities which correspond to hearing in the areas which are directly connected with the ear. The difficulty with this view is that the areas in question are separated from one another in such a manner that it seems unlikely that they can combine into an electrically unified process. If such a combination occurs it can only be through the nerve fibres running from the separate sensory areas to the association areas. In order to effect the combination, nerve currents must pass from all the sensory areas to the association areas. Hence in the association areas there will be a flowing together, in close union, of currents from all of the sensory areas. The details of the activities in the several sensory regions must be represented in the currents which combine in the association zones. Otherwise these details can have no influence upon the resulting motor discharge. Now, if such a detailed, combined representation of all the sensory activities is actually passed on to the association regions *it would seem that the nerve processes here can furnish a sufficient basis for the whole of consciousness.*

This view becomes even more plausible when we realize that memory records are laid down almost wholly in association regions. Those interconnecting synapses which we have discussed so thoroughly are almost certainly located in the association zones of the cortex. Since memory must reproduce the basis of consciousness, it is natural to suppose that consciousness has its basis where memory is laid. Every group of nerve currents which passes through the cortex leaves its impress upon the association synapses, and these impressions influence subsequent nerve currents. Now it is unlikely that all of these different records can be laid down in the same synapses. This would tend towards confusion, although it is very probable that a single synapse can be used more than once, as a member of different nerve current arrangements. The association areas are large and complicated, and hence we may reasonably suppose that the exact location of the central process in these areas is subject to change. Only a relatively small portion of the association surface is involved in any single instant of consciousness. As time goes on, and as the nature of the consciousness changes, the central activity shifts from one group of synapses to another.

We may compare the central process to a spot of light which is produced by the focusing of myriads of fine rays upon the cortical surface. The rays represent the incoming sensory nerve currents. They pass through their respective receiving stations in the cortex and are then concentrated in a definite pattern upon some particular section of the association areas. The position of the light spot fluctuates and also varies progressively in its general location during the lifetime of the individual. However, the motion of the spot is continuous; it never jumps suddenly from one position to another. This represents the continuity of our experience. Each consciousness blends smoothly into its predecessor and successor. In the normal individual there is only one central light spot upon the cortex at any one instant. However, in cases of double or multiple personality there may be two or more light spots. It is of course understood that the light spot is only an analogy, the actual process being a unified electrical activity of the type which we have discussed in our description of the nerve impulse.

The Basis of Attention

Although each normal individual has only a single central light spot there is a great deal of luminescence in the regions which surround it. This corresponds partly to the rays which are on their way to the central focus, but some of it is due, so to speak, to a scattering of these rays before they reach their proper destination. If the central spot represents the central (introspective) consciousness of the given person, then the surrounding activity in the association region can stand for the so-called *subconscious* mind of this same person. The outlying cortical activities influence the central process in an important way without forming an integral part of the process in question. In some cases they may even influence the outgoing nerve currents directly, without acting through the central spot. Ordinarily, however, all of the outgoing currents emanate from the latter.

The idea of the subconscious mind can be defined in several different ways. From the standpoint of consciousness it is best considered in relation to the phenomena of *attention* (which we have already studied in their general relation to action). The older psychologist regarded attention as a peculiar activity of the mind which was based upon a special faculty. Modern psychologists have endeavored to give a structural account of attention. According to this account every moment of experience has a definite attentional *form.* The so-called activity of attention consists of changes in this form or in its contents. We must first consider just what kind of a thing the attentional form is. Every consciousness is limited in its size and scope and may therefore be said to have a *boundary.* There are some things which are inside of consciousness and others which are outside of it. The boundary lies between these two groups. The things which are inside are the parts or components of consciousness, and the things which are outside make up the rest of the universe. (Fig. 22.)

Although it is thus possible to set a boundary to the domain of any given consciousness, this boundary is not perfectly sharp or clear-cut. Some parts of consciousness are very clear or vivid. Others are vague and ghostly, as if they were on the verge of stepping out of consciousness altogether. Between these extremes there are numerous possible gradations. The situation is as if some things were wholly in consciousness while others are only partially there. At any rate, the different portions of consciousness exhibit differences in *clearness*. It is therefore possible to consider the structure of consciousness in terms of clearness, and this structure assumes the form of a circle. The center of the circle represents the few parts which have great clearness, while the periphery stands for the larger number of parts which have vanishing clearness. Between the center and the periphery are other factors possessing intermediate degrees of clearness.

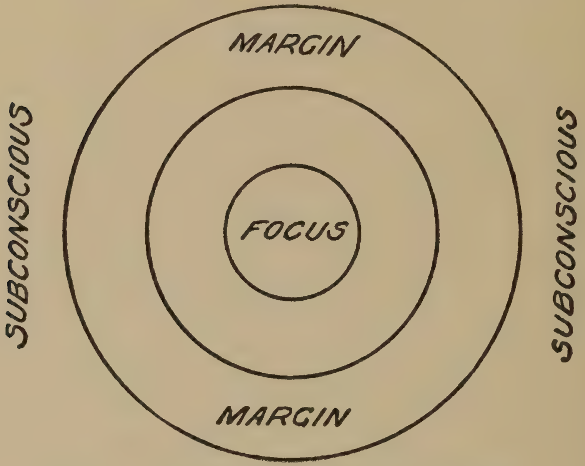

FIG. 22. ATTENTIONAL STRUCTURE OF THE MIND.

Representing symbolically in terms of space relations the organization of consciousness into focus, margin and subconscious.

The comparison of the attentive form of consciousness to a circle is of course only an analogy. In order to realize the exact nature of this form, we must turn to some actual consciousness and observe it directly. Let us consider a concrete illustration. As I sit now in my chair the clearest constituent of my consciousness at the given moment is the visual presentation of the paper and mechanism at the writing point of my typewriter. Less clearly represented are the remaining portions of the typewriter and other objects in my field of vision. The sound made by the type in striking the paper is also less clear than the visual representation of the writing point. Even less clear is the touch sensation due to the pressure of my fingers upon the keys; and less clear still that due to the pressure of my body against the chair in which I am sitting. But there are factors in my consciousness which are even vaguer than these: the odor of a smoldering cigarette at my side, and the tick of a clock in an adjoining room or the rumble of a passing trolley car.

It will be appreciated that this arrangement of the parts of consciousness in the order of their clearness has very little to do with their inherent nature. There is nothing about the visual representation of the typewriting *per se* which causes it to be of the greatest clearness. The faintness of the clock-tick does not necessarily mean that it must be unclear in consciousness. In an instant the attentional structure of my consciousness may change so that the clock-tick becomes the central feature and the visual factors recede into the background. When this happens we say that attention has been directed to the clock and away from the typewriting. However, this does not *explain* what has occurred; it merely points to the actual fact of a shifting of the relative clearnesses of different portions of consciousness.

The Nature of "Interest"

Nevertheless, we naturally wish to know the causes which underlie such shifts of clearness. This means understanding the basis of clearness in all cases. We appreciate in general that attention is controlled by *interest.* I attend to my typewriting because I am interested in seeing the result. If my attention shifts to the clock-tick it is because I develop an interest in the clock, for example, as to whether it is still running. The question therefore arises as to the exact nature of an interest. Is interest something which can be defined in terms of consciousness, or must we look for its basis in the physiology of the nervous system? When we say that a thing is "interesting" we may mean merely that it commands our attention, without our knowing why. On the other hand, there are certain fairly definite characteristics of things or ideas which seem to "make" them interesting. Pleasantness and novelty are features of this sort. Intensity and suddenness are also effective. Unpleasantness operates as a negative interest, turning attention to means of avoiding the unpleasant thing.

A fundamental explanation of interest is almost certainly not to be found in any single moment of consciousness. The explanation must be sought in the biography of the individual, and this biography is written in his cerebral cortex. It is written — if we are to believe all that has been said in previous chapters — in terms of the resistances of his cortical synapses. The physical foundations of interest must be looked for in the synapses. Generally speaking, we are interested at any moment in the thing which is the object of our response at that moment. Those incoming nerve currents which pass through the cortex *to determine our behavior* are the ones which at the same time determine what shall be clearest in consciousness. The perceptions, ideas, etc., to which we are said to attend are due to the central passage of impulses which are destined for voluntary muscles.

Our discussion of the processes of the nervous system in previous chapters has revealed the principal factors which govern the passage of incoming nerve currents through the cortical synapses. If no habits have yet been formed it is determined by the intensity of the currents and by accidental conditions in the synapses. If the resulting behavior brings pleasantness due to the stimulation of sensory encouragers, the given form of conduction will be strengthened through a decrease in the corresponding synaptic resistance. This starts the formation of a habit, so that the next time the same stimulus appears, its nerve currents will pass through the cortex more readily. An association is also established between the given nerve currents and the encourager activity which tends to build up the habit further and become an instrument in the formation of other habits. We have called such an association a complex. Habits and complexes furnish the main foundations of interests, and, hence, are the dominant factors in controlling attention as well as behavior.

The Nature of the Subconscious

Let us return now to the phenomena of attention or clearness as they exist in consciousness, to see what bearing they have upon the notion of the *subconscious mind.* We have seen that consciousness has a boundary within which there are various parts, having differing degrees of clearness. Those parts with the least clearness are nearest to the boundary. Hence, we suppose that degree of clearness is the characteristic which determines whether a thing will be in consciousness or not. It seems self-evident that to describe something which has no clearness at all, is to describe something which is not in consciousness at all. The most general statement which we can make concerning things outside of consciousness would seem to be that they have zero clearness. This is really what is meant by saying that they are "outside." We cannot use the word "outside" here in the narrow sense of exclusion from a certain *space.*

It would seem that all things which are "outside" of consciousness in the sense of having zero clearness must be of *equal* clearness. All zeros are of the same magnitude. However, it seems that there is a degree of clearness so small that it is practically zero, without being theoretically zero. This means that there can be portions of consciousness which are so vague that no report can be made of their nature, and even so vague that their presence is not recognized by thought. Such factors are practically out of consciousness at the given moment, but since they are on the edge of consciousness they are in a favorable position to jump into the center. In other words, things which are for all immediate practical purposes outside of consciousness, may differ radically in their chances of coming into consciousness. Some are hovering on the border, while others are very distant in this sense.

Now, every man believes that there is a vast universe of realities outside of his own immediate consciousness; but some of these are *mentally nearer* than others. The collection of things which are most intimately connected in this manner with my consciousness may be known as my subconscious mind. The subconscious thus consists in ideas, perceptions, sensations, feelings, etc., which are on the verge of becoming clear. They are potential features of clear consciousness, but at the given moment they are not actual. Nevertheless, they are to be conceived as having just as much reality by themselves as have the demonstrable parts of consciousness. The relation between the conscious and the subconscious is similar to that which holds between any two individual consciousnesses. Your consciousness and mine are separate from each other. Yet they are equally real; and they are of the same general nature. However, your thoughts and perceptions are not associated with my consciousness in such a manner that they strongly influence it or can "pop" into it except through the complicated channels of sensation. My subconscious, on the other hand, is a mentally close-up reservoir of materials for my conscious field. The subconscious as thus defined consists of the same kind of stuff as consciousness itself. It is made up of qualitative factors: sensations, images, pleasant and unpleasant feelings and the like. Its processes resemble those of the conscious mind: it has thoughts, imaginings, desires, emotions and so on. It is not composed of electrons or protons or any other physical or physiological elements.

The Physiological Basis of the Subconscious

If this is the case we shall do well to ask whether there are any physiological factors which *correspond* to the subconscious. This correspondence would be on the same principle which we have applied to consciousness in relation to the so-called central activity in the cortex. However, instead of approaching this question from the mental side we might consider it from the side of the nervous system. We have found reason for believing that the ordinary consciousness of any individual is correlated with nerve structures and activities which are localized in a restricted part of his cerebral cortex. We have compared this "central" brain process to a spot of light on the cortical area. Now, the reader is entitled to ask why consciousness should be associated with this particular nerve activity and not with others. If consciousness is one thing and the central nerve process is another, then it is possible that they have been tied together arbitrarily, as by an act of the Creator. However, modern science tends not to regard facts in this way. It seeks for a general principle rather than special creation as an explanation.

In the case of the ordinary individual consciousness, it appears that the central brain process as we have depicted it, is the only activity which is physically fitted to underlie this consciousness. Only in the central process do we find a unitary combination of effects derived from all of the senses. Only here is there available a record of past experiences; and from no other point can there be exercised a centralized control over all of the voluntary muscles. Consciousness represents all of these features in detail, and hence it must be associated with the nervous activity which possesses them. The situation is much the same as the one in which we find that the Jones' consciousness is related to Jones' brain and not to Smith's. Smith's brain does not have the right nature or history to determine the Jones' consciousness.

However, we still have the most difficult part of the problem before us. We can understand why particular consciousnesses are associated with particular nerve activities. But if consciousness goes with one nerve activity why should it not accompany all? What is there that is peculiar about central brain processes in general which causes them to be linked with individual consciousnesses? We can point out certain salient characteristics of the central processes which tend to differentiate between them and other nerve activities. They are foci of a multitude of simultaneous nerve currents. They combine these currents so as to form a unified electrical structure or process. They dominate the voluntary musculature. However, some of these characteristics are merely matters of external relationships. Others simply involve questions of degree. If unification of many components is required to yield consciousness, then we should expect to find consciousness wherever such unification exists.

Sentiency

The solution of this problem, so far as we are able to see at present, lies in admitting that something very like consciousness is probably associated with *all* nervous activity. Let us call this something *sentiency*. Now sentiency is not a property of the nerve processes, and does not reside in the nerves. It merely exists when nerve action exists, and its nature varies with the nature of the nerve action. *Where* the sentiency is located is a question which we cannot answer, because the question is a foolish one. However, some of this sentiency is intimately connected with my individual consciousness, and constitutes my subconscious mind. It is reasonable to suppose that this is the particular sentiency which is related to nerve activities which closely outlie my central brain process.

The Boundaries of the Subconscious

If we take this view of the situation the chief problem seems to be as to why the subconscious sentiency is not included in consciousness. What determines the boundary between them? The answer is not far to seek. The formation of a consciousness is a matter of unification. The subconscious is not part of the conscious because it is not linked to it by bonds which are sufficiently strong. Hence, we may naturally suppose that the nerve activities which outlie the central process do not unite with the latter by means of electrical force fields of any appreciable intensity. It is the strength and continuity of such fields which underlie unification such as we find in consciousness. The non-central nerve processes may form electrically coherent groups among themselves but they do not combine in this way with the central activity. Hence, their corresponding sentiencies do not form a union with consciousness.

It will be noted that no particular portion of the cortical association areas is assigned to the subconscious as opposed to the conscious mind. This is because we have conceived the central focus of nerve activity to fluctuate in position over the association surfaces. However, memory records are laid down in definite places, which are determined by the momentary location of the central activity which produced the memory record. When the record was being made, the corresponding sentiency was a part of consciousness. However, at some later time the cortical focus shifts to a new region and the memory furnishes a basis for subconscious sentiency. Thus, under ordinary conditions, the subconscious is mainly concerned with memories and memory effects, including habits, complexes, and the like. Consciousness is also very largely influenced by memory, but the memory effects which appear in consciousness at any given moment are relatively few in number.

The Relations of Conscious and Subconscious

In its most significant aspect, consciousness corresponds to the *recording point* in the brain. It represents the "moving finger" which writes upon the cortical surface. The central brain activity is a formative process. What it writes is determined to some degree by what has already been written at the place where the record is being made. We thus conceive of the central activity as wandering about over the association areas, always leaving its impress behind it. The residual activities which continue on the basis of these impressions correspond with the subconscious mind. The wandering focus of activity corresponds with consciousness. The central activity very frequently retraces its movements or walks in some of its own footprints, thus bringing the material of the subconscious into consciousness, and combining the memory influence with that of the present forces of sensation.

This view leads us to regard the subconscious on the one hand as *the product of consciousness*, and on the other hand as a vast *storehouse of materials* for the latter. Having once discovered these functions of the subconscious, we can substitute the latter for the brain in our explanations. Thus instead of explaining habit in terms of synaptic resistances we can account for it in terms of some "subconscious tendency." Complexes regarded as nerve mechanisms will give way to emotional ideas, or the like, regarded as facts of the subconscious. Thus we develop a purely psychological system which endeavors to account for the phenomena of consciousness in terms which are similar in kind to those in which consciousness itself must be described. The physiology of the cortex is to a large extent eliminated. This does not mean that we deny the existence of the cortical structures and activities, but only that we can get along without referring to them. Freud's account of his famous theory is given primarily in terms of a sentient subconcious rather than in terms of brain mechanisms.

It is doubtful whether the doctrine of the subconscious offers any very important advantages over that of brain activity as an explanation of conscious life. We know little enough about the brain, but we know practically nothing about the subconscious. In both cases we rely upon speculation and plausible guesses. However, the question as to the utility of the subconcious as a means of explanation has relatively little to do with the question as to whether the subconscious exists. We must decide the latter question on the basis of general principles. These are the principles which we have already applied: if consciousness is associated with the central brain activity, why should there not be something similar to consciousness (sentiency) in association with other brain and nerve activities? It is entirely possible that an answer can be given to this question which will show why consciousness or its like must be restricted to the single central process in each nervous system. But no such answer has yet appeared in the history of psychology or philosophy. Hence, we feel justified in believing in the reality of the subconscious, no matter how vague our conception of it may be.

Sentiency Beyond the Subconscious?

When we accept this conclusion we expose ourselves to new philosophical obligations and dangers. What is there in particular about nerves and nerve activities which causes sentiency to arise in correspondence with them? In what way are they peculiarly different from other material structures and processes in this respect? In answer, we must say that if any such peculiarities exist they must be affairs of structure or organization. The modern physical view of the world, which we have depicted in previous chapters, does not allow that there are any fundamental differences in kind between various parts of the physical universe. The only exceptions to this statement are in the cases of the elementary constituents of the entire physical system, viz., electrons, protons, space and time. But every nerve process involves all of these basic factors, and, hence, cannot be distinguished from any other material process with respect to them.

The central activity in the cerebral cortex is physically nothing but a tremendous number of protons and electrons going through special motions under the influence of their electrical and magnetic fields. Exactly the same statement applies to any brick in the wall of my house, or to a dust speck in the air. The difference between the nerve process and the brick is simply a matter of the *way* in which the electrical particles are put together and the *way* in which they are moving. However, this question of structure and form of activity is of the utmost importance in physical science, because nearly all differences must be reduced to it. Consequently, it is quite possible that we may be able to find out what particular sort of structure and motion is required in order that sentiency should arise.

The fact remains, however, that the necessary discovery has not yet been made. This is true in spite of the fact that psychologists have expended a great deal of energy in the endeavor to formulate so-called "criteria of consciousness." The problem seems easy at first. We can say that consciousness or sentiency requires a living organism. But we soon find that only a small portion of the organism is needed, viz., the nervous system. A little further investigation reveals the fact that only a small part of the nervous system, the cerebral cortex, is necessary. The farther we pursue the question, the more the determination of consciousness seems to narrow down to a matter of general physical properties and a special location in the brain. The general physical properties are those which we have discussed in our study of nerve action. The special location is that of the central activity in the cortex at any moment.

Now it is true, of course, that the physical nature of nerve action is somewhat special in character. If this were not so, all physical processes would be nerve processes. However, the uniqueness which the nerve mechanism exhibits is attained only by combining a number of features each of which can be found separately in many other physical systems. Moreover, the whole assembly of features can be found elsewhere in somewhat less perfect combination. Thus, the possession of an electrical double layer (polarization) is a common property of all living cells. It is found in muscle as well as in nerve, in liver cells as well as in brain cells. It is present in the single cell which constitutes the entire organism of the lowest of all animals, the amoeba. It also exists in the active cells of plants. The reduction of this layer as a consequence of stimulation is also a general effect which is observable in all cells. These processes are more strongly developed in nerve cells than in other living units but the difference is one of degree rather than kind. In fact, it is a general principle of biology that the fundamental living material, protoplasm, possesses to some extent all of the properties which are specially emphasized in particular tissues or parts of a complex organism.

If we consider the separate features which are combined in the structure and activity of a nerve cell, we find that any one of them can be found in some inorganic, non-living, system. A piece of iron wire immersed in an acid solution, shows properties very similar to those of a nerve fibre. It develops an electrical double layer, and when this is disturbed, the disturbance is propagated along the wire in a manner resembling that of the passage of a nerve impulse. But the wire is made of iron and not of nerve protoplasm, and the wire does not show the same recovery from disturbance and power to repeat its response which the nerve exhibits. However, recovery from other types of disturbance, rapidity of action, etc., can be demonstrated in many other non-living mechanisms.

We thus find it difficult if not impossible to specify any peculiar properties of nerve structure or action which single it out as the physical associate of consciousness. In this situation we can follow either one out of two possible courses. We may say, on the one hand, that we believe that such peculiarities exist and will eventually be discovered. Or we may assert, on the other hand, that the alleged uniqueness is non-existent, and hence that something of the nature of consciousness is associated with all physical realities. This latter view has been known to philosophers for a long time as *panpsychism*, the doctrine that there is mind everywhere. It is closely related to the philosophical teaching known as *idealism.* It differs from idealism, however, in that the latter denies the reality of the physical world, while panpsychism does not necessarily do this. In the next chapter we shall endeavor to present a clear analysis of these traditional theories in the light of modern psychological facts. In this analysis the "mystery of mind" may deepen but at the same time we shall penetrate it even further and dispel the confusions which surround it on a less philosophical plane.

CHAPTER XV

THE SUPERCONSCIOUS MIND

WHAT do we mean by saying that "something of the nature of consciousness" is associated with all physical reality? We mean that for every physical particle or combination thereof, there exists a corresponding sentient unit or combination. What is a sentient unit? It is a thing like a sensation or a feeling. It is something which is characterized by quality rather than by quantity. It may be like a color, a musical tone, a pleasure, or a pain. It cannot be positive or negative electricity, or empty space or time. In beginning to consider the theory called panpsychism we must thoroughly dispell from our thinking two impressions which if retained will prevent us from ever understanding the theory. The first of these is that sentiency is less real and more difficult to think about than is matter. The second is that sentiency can ever actually *reside* in matter. There is nothing that we know directly and beyond dispute except our own consciousnesses, and sentiency is of the same nature. Our examination of the relationship between the brain and consciousness must have made it quite clear that a man's consciousness is not located in his cerebral cortex, although the physical factors which determine his consciousness are located there. The same situation holds for the sentiency which is associated with any particle of matter (or electricity) whether in the brain or elsewhere.

Deducing the Panpsychic Universe

Since the physical universe is now regarded as being exclusively composed of electrical particles, it is advisable to speak of electrical rather than of "material" structures or processes. It will be understood that the words, "physical," "material," and "electrical" have substantially the same meaning. The doctrine of panpsychism therefore reduces to the statement that for every electrical particle or structure or change there is a corresponding psychical particle or structure or change, respectively. However, the electrical and the psychical are quite different from each other and they are not located in the same space. The doctrine is really very simple. We first obtain the physicist's map of the universe, and using this as a guide we construct a corresponding map of a sentient universe which we suppose to exist.

However, if the reader were actually to be confronted with this map-making task he would undoubtedly feel himself at a loss. In the first place he might have difficulty in understanding the map which is presented by the physicist. The intricacies of modern physics are not altogether easy to follow. The most complete physical descriptions are full of mathematical terms which are unintelligible to the uninitiated. We may suppose, however, a reader who is perfectly conversant with all of these technicalities. The next difficulty now appears in determining the rules according to which the panpsychical map is to be derived from the physical one. The most learned of physicists can tell us nothing from his own science which will help us here. We must turn to the psychologist, one of whose duties it is to study the relationships between electricity and consciousness.

Now, we have considered these relationships in some detail for one particular case. This is the case of the human consciousness in relation to the human central (cortical) brain process. It is quite conceivable that this single instance will reveal all of the rules which are needed for our panpsychic map-making. General scientific principles are always worked out in practise by studying a limited number of concrete examples. Unfortunately, as we have seen, our experimental knowledge of the relationship between the brain activities and consciousness is rather meagre. Consequently we are compelled at present to content ourselves with plausible inferences and hypotheses.

The nature of some of these plausible views has already been indicated. We have supposed that the physical structure of the central brain process corresponds in a general way with the structure of consciousness. For every distinguishable part of consciousness there is a corresponding part of the brain process. The *way* in which the two sets of parts are put together is their *structure*. Now, we have conceived that the two structures — physical and psychical, respectively — have a general similarity. They are mathematically or logically similar. This means that for every relation between parts in the conscious structure there is a corresponding relation in the physical structure. However, if we compare any two corresponding relations we may find that in themselves they are not very similar. For example, the relationship between two brain parts may be that of electrical repulsion, while the corresponding relationship between the corresponding two portions of consciousness may be that of clearness of separation — as between a black and a white line in the visual field.

However, some corresponding relations may show a very considerable degree of similarity. This will be especially true in the case of forms of consciousness which have a clear spatial structure. The corresponding brain pattern must also be spatial in nature. Thus, in the case of the visual perception which we call the American flag, there are white stars against a blue field and white stripes alternating with red ones. The brain process which corresponds with this perception will have parts for each of the stars, other parts for the field, and still further parts for the stripes. It seems very doubtful whether this brain process structure will faithfully reproduce the flag form, but it is highly probable that the parts for the stars will be spatially juxtaposed to those for the field, and that the latter in turn will be adjacent to the parts which correspond to the stripes.

Chemistry and Sentiency

These principles must be supplemented by rules concerning *quality* and *unity*, the general character of which we have outlined in previous chapters. We have noted that consciousness is apparently not as complex in structure as the corresponding brain activity. At the same time it is much more diversified. If we reduce the brain to protons and electrons, its diversity is limited to two different kinds of elements. However, even in the single instance of the American flag we find at least three different species of elements on the conscious side: red, white and blue. We have therefore concluded that qualitative differences, such as that between red and blue, must correspond with fine structural differences between various small aggregates of protons and electrons. Examples of such aggregates are to be found in atoms and molecules. Since the number of different kinds of atoms is far smaller than the number of different qualities (sensations, etc.,) which are found in consciousness, we must suppose that the aggregates in question are usually as large and complex as molecules.

One way of putting this principle into concrete form would be to say that for every different chemical substance there is a distinct sentient quality. However, the facts are probably more complicated than this. The state of the substance and the processes which it is undergoing must also enter into the determination of the corresponding quality. Distinctive qualities must also exist in correspondence with physical structures which are more complex than chemical molecules. A crystal is a possible example of such a structure. The nerve membrane is another. The "state" of a substance is represented by its intimate internal structure; whether it is crystalline or "amorphous," under tension, charged with electricity, etc. Its processes involve such things as its temperature, its participation in an electric current, its chemical reactions, etc. The nature of the structure determines the processes, and the latter in turn are reflected in the structure, so that it is possible to combine these two aspects into a single resultant.

In accordance with these principles, the ultimate components of the physical system — the electrons and the protons — fail to find distinctive representation in consciousness. The smallest parts which achieve such representation are at least as complex as molecules. We have already considered the explanation of this fact. It is because the ultimate electrical particles are so firmly united in these small structures by their connecting electrical field that they form combinations having a high degree of unity and individuality. The physicist tends to overestimate the persistance of electron and proton individuality in such combinations. The essential fact about them is the existence of a continuous electrical field which has a characteristic form or contour. This field form is the fact which is directly related to the corresponding qualitative characterstics in consciousness.

The degree to which a given aggregate of electrons and protons is represented by qualitative rather than by evident structural appearances in consciousness is proportional to the concentration of the electrical forces which hold these particles together. A great deal of electrical force or energy in a small space means great unity and distinctive quality rather than structure in consciousness. However, there is some qualitative effect even with the most diffuse kind of electrical union. Quality passes over into structure progressively as unity decreases. Consciousness as a whole must correspond to a physical system (the central brain process in the cortex) which has a considerable degree of electrical unification. Hence, each different consciousness will tend to have a distinctive general quality all its own.

Sentient Boundaries

The boundaries of consciousness or any similar sentient structure must be determined by the limits of electrical unification within the corresponding physical system. Lack of such unification is a condition which is not difficult to find or to establish. Two protons, or any two bodies of like electrical charge can have no electrical unity. In fact, they have the opposite of unity, a kind of negative unity, which is indicated by the fact that they repel one another. No lines of force connect them. Their electrical fields bend away from each other. In order to combine two protons, at least one electron must be introduced into the situation. There is also practically no electrical union between distant aggregates, each of which consists of electrons and protons in equal numbers. Such aggregates form neutral, unelectrified, material bodies. Some slight degree of electrical attraction probably operates between all bodies in the physical universe. However, the amount required to yield a system like the human consciousness is undoubtedly much greater than this minimum. Otherwise this consciousness would correspond to a much larger portion of the physical world than the restricted central activity in the brain.

These are the most important general principles which are needed in order that we should be able to construct a map of the panpsychic "universe of sentiency." However, to make such a map complete and definite we require more specific information. What is the exact chemical constitution and physical state of the substance in the brain which corresponds to "blue"? Or, conversely, what is the sentient quality which corresponds to the substance, nitrobenzene, at ordinary temperatures? Such specific information is not at hand, and there seems to be no way in which we can arrive at it by logic or plausible guesswork. Nevertheless, it is entirely conceivable that progress in physiological psychology will yield this definite, detailed knowledge concerning the interrelations of consciousness and matter. There is no fundamental reason why we cannot trace the visual nerve impulses to their central destinations in the brain and discover exactly what happens there when blue is seen. This is a laboratory problem which cannot be solved in the author's armchair.

The Rôle of Feeling in the Panpsychic World

There is one case, however, in which we shall dare to develop a rather detailed specific theory. The merits of this theory may consist primarily in its value as an illustration of the kind of thinking which must be done upon these problems. The theory relates to the significance of *feeling* for the sentient universe at large. It indicates an intimate association between pleasure and the *dynamics* of things. In outline, the doctrine is as follows.

We have developed in previous chapters a view which relates feeling to the changing of resistance in a nerve synapse. According to this view, pleasure is associated with a decreasing of such resistance, while displeasure — or unpleasantness — goes with an increasing of the same. The intensity of the pleasantness is supposed to be proportional to the rate at which the resistance is decreasing. The intensity of the unpleasantness is similarly determined by the speed of increase. In our studies upon the physical nature of nerve activity we have seen that the resistance of a synapse is probably an inverse representation of its excitability. That is, the higher the excitability the lower the resistance. The excitability is a property of the membrane which surrounds the nerve cell in the region of the synapse. We have also seen that the excitability probably depends upon the degree of porousness of this membrane.

When the membrane is very porous the excitability is low; when the porosity decreases the excitability increases. Putting these various facts together, we find that a decrease of resistance means a corresponding decrease in porosity.

Pleasantness and "Congregation"

From these considerations we may argue that pleasantness accompanies decreasing porosity, and is proportional to the rate of such decrease. Unpleasantness goes with increasing porosity and is similarly proportional to the rate of increase. When the porosity remains constant, regardless of its fixed value, the corresponding conscious state is one of "indifference." In order to apply these principles in a panpsychic investigation we must know more about the physical nature of porosity changes. Now there is more than one way in which the porousness of a membrane can be altered. The particles which compose the membrane may be rearranged so as to change the shapes of the openings between them. Another way is by all of the particles coming closer together, by a shrinkage of the membrane along its surface or possibly perpendicularly to the latter. A third method would involve the introduction of new particles which plug the pores between the old ones. There is a common tendency in all of these modes of alteration, however, and that is the tendency for all of the particles which are concerned to *congregate*, or to come into closer proximity with one another.

In general, if some of the particles in the membrane did not come more closely together, there could be no decrease in the porosity. The porosity is determined by the ease with which foreign particles can pass through the membrane. In order to impede the passage of such particles it is obviously necessary to block the holes through which they would otherwise move. Such blocking requires that the particles surrounding the holes should move towards one another, or else that new particles should be inserted between them. Such new particles would differ from those which pass through, in that they combine with the membrane and become part of it.

Now the process of "congregation" of particles is a very common one in the physical world. In fact, it is one of the most general and universal of physical actions. All material structures whatsoever may be conceived as having been formed by this process. Atoms are produced by the congregation of electrons and protons. Molecules result from the congregation of atoms. Solid and liquid bodies are the outcome of a congregation of molecules. The living organism represents a congregation of cells, and so on. Hence, if we can relate feeling with congregation we shall have a general principle with a wide range of application. Of course there is a great deal that is speculative in this reasoning, but let us continue and see where it leads us.

The first question which we must ask is as to why physical particles tend to congregate. We may begin with the fundamental case of the electron and the proton. Here the explanation is found in the law of the electrical attraction of opposite electrical charges. The electron is a negative charge and the proton is a positive one. The field of electrical force which stretches between them behaves like a bunch of rubber bands which draw the two particles together. In this case congregation results from a yielding to forces of mutual attraction. If we believe that a pleasant feeling always accompanies congregation, then we must suppose that when an electron and a proton rush towards one another, the corresponding sentient units are suffused with pleasure.

Feeling and Energy Transformation

We may wish to estimate the intensity of this pleasure. In this case we may consider the velocity of the movement or, better, the quantity of energy which is involved. The motion of electrons liberates energy which has been stored up in their electrical fields. In the stored form the energy is called "potential," and is represented by the stretched condition of the "lines of force" which make up the fields. The case is analogous to that of a rubber band which is under tension. When the electron and proton move together some of this energy becomes "kinetic," or is transformed into energy of motion. We may therefore reasonably suppose that the intensity of feeling in this situation is proportional to the *rate* at which the energy is being changed from potential to kinetic form. It corresponds, so to speak, to the speed at which the system is carrying out its inherent tendencies to action.

Here, however, we encounter a difficulty. The case in which two particles attract one another is not the only one in which potential energy can be released. This can also occur when two electrons or two protons act upon each other. It is a fundamental law of electrical science that like electrical charges repel one another. If they are allowed to follow this tendency they are set into motion and thus convert the potential energy of their repulsive fields into kinetic energy. Consequently we are faced by a situation in which we must make a choice. Shall we relate pleasure in general with congregation or with the release of potential energy? If we accept the latter alternative, we must admit that in the case of like electrical charges pleasure goes with the opposite of congregation. Since we have no experimental facts which bear upon this question, we can only be guided by the general persuasion that pleasure should accompany the unconstrained activity of any group of particles which is allowed to work out its own inherent tendencies. This is an inference by analogy from the human being who is most happy at the moment, when he is permitted to do what he "wants" to do. The inference leads us to adopt the general principle that *pleasant feeling is always associated with the release of potential energy and is proportional to the rate at which such energy is being liberated.*

It is an evident corrolary of this principle that the reverse physical process should be accompanied by *unpleasantness.* When kinetic energy is disappearing and is being stored up in the form of potential energy, the associated sentiency should be unpleasant in proportion to the speed at which this change is taking place. When the amounts of potential and kinetic energy remain constant in all parts of the system of particles, the accompanying sentient state will be one of "indifference."

If we pass from electrons and protons to more complex physical processes we find that the same general principles can hold. When atoms combine to form molecules there is a release of potential energy. This becomes kinetic as heat or as mechanical motion, as in the case of an explosion. Similar energy release of a less intensive character occurs when molecules unite to yield larger masses of matter. Physicists believe that the congregation of atoms and of molecules depends upon electrical forces similar to those which bring electrons and protons together. In fact, it is almost certain that these forces are identical with portions of the electron or proton fields which have not been exhausted by the original union of the smaller particles.

The Struggle for Pleasure

If we survey the universe at large we find that action due to attractive forces is much commoner than that due to repulsive forces. The reason for this is that repulsive forces are constantly acting so as to weaken themselves, while attractive forces behave so that they make themselves stronger. This is made possible by the fact that the strength of an electrical field diminishes very rapidly as the particles are separated from one another in space. The action of repulsive forces is usually conditional upon their entanglement with attractive forces. Such entanglement is inevitable in any physical system which consists of more than two particles. If there are only two particles one can be positive and the other negative; but if we add a third it must be either positive or negative. If it is positive it will act repulsively upon the already present positive particle. If, on the other hand, it is negative it will stand in the same relation to the negative particle which is already in the system. Since large numbers of protons and electrons are capable of combining into well unified groups it follows that the attractive forces overcome the repulsive ones on the average.

If we accept the above reasoning we must conclude that *the sentient universe as a whole is governed by a hedonistic law.* By this we mean that all changes which occur in this universe are controlled by a pleasure tendency. For potential energy will always be transformed into kinetic energy when restrictions are removed. Such restrictions usually involve a balancing of one potential energy against another. Thus, if we hold a rubber band in the stretched condition, the tension of the band is balanced by the tension in our muscles and bones. When the connection between the two is broken — as by letting go of the band — both systems of energy are released. Such states of balance or of equilibrium are the conditions of no activity and are accompanied on the sentient side by "indifference."

It may seem that in a universe which is governed by a tendency towards pleasure, the existence of unpleasantness or misery forms a mystery. However, it is evident that we can specify the conditions of unpleasantness from our theory. Unpleasantness will appear whenever kinetic energy is being converted into potential energy. Under what circumstances does such a transformation take place? A study of many instances shows that a conflict between two systems of energy is necessary. In such a conflict the more powerful of the two systems forces the other to follow its will. The weaker system is thus forced into a form of action which it would not pursue if it were left free. The unpleasantness is associated with the process in the weaker system, and is always less than the pleasantness which goes with the success of the stronger of the two systems.

The physics of this situation is well illustrated in the act of stretching the rubber band by muscular energy. The potential energy which is stored in the muscles overcomes that of the band at all stages of the stretching. The band may break, in which case its energy immediately returns to kinetic form. On the other hand, if the band is a very heavy one, it may eventually accumulate enough potential energy so that our muscles become unable to stretch it further. The energy transfer in this experiment is evidently from the muscles into the rubber band. The structure of the entire system, including muscles and band, is such that only a portion of the muscular energy can go over into kinetic form, and in doing this the remaining portion moves from the muscles into the band. The sentiency which corresponds to the band is suffering at the expense of that which corresponds to the muscles, because the band is having potential energy piled up in its structure while the muscles are reducing their store of this commodity.

The analogy between these principles and those which apply in human affairs is quite evident. Unpleasantness is usually the result of some kind of conflict. Sometimes the conflict is between human tendencies and those of inanimate nature, as when I burn my hand on a hot iron. Other times the conflict is between different human beings, as in war. On still other occasions, there is a struggle between different components of a single personality, as in worry, indecision, and the forms of mental disease which are much discussed by Freud. Pleasure, on the other hand, accompanies the free pursuit of any individual's own tendencies, unhampered by natural, social or internal interferences. Pleasure also results when the individual is able to overcome such sources of interference.

Sentient Evolution

The universal process which we call *evolution* can be described in a general way in the terms outlined above. In the first place, evolution consists in an ever increasing complexity of physical structure. It begins with isolated electrons and protons. These congregate to form atoms in a series having increasing intricacy. The atoms, in turn, combine into molecules and the molecules into cells and the cells into organisms. A conflict goes on unceasingly between all of these structures and the forces which they involve. As a consequence of this conflict some of the structures are broken up and disappear from the scene. Those which remain do so because they have the greatest stability, and because they conflict with one another the least of any of the structures which have been produced. The human and other living organisms owe their peculiar forms and functions to these principles.

On the sentient side, the increasing complexity which we find in the evolutionary series is an evidence of the striving for pleasure. The so-called "fitness" or "adaptation" of the organism to its surroundings or conditions of physical existence, is an outcome of the resolution of conflicts. As such it indicates a tendency towards the establishment of conditions under which unpleasantness is rendered less likely than would be the case in a more primitive state. Evolutionary progress is therefore the outcome of a "blind" pleasure-seeking activity, which becomes enlightened through its failures and pains. On the high level of human consciousness this enlightenment may take the form which we call intelligence.

Other Aspects of the Sentient Universe

This understanding of the universal significance of feeling — if it be correct — is a very important feature in our appreciation of the sentient universe as a whole; but it must be supplemented by many other principles which are at present unknown. When a hydrogen atom and an oxygen atom are in the act of combining, the corresponding sentiency will be suffused with pleasure, but it will also possess other characteristics. These latter are related to the special structual arrangement and the inherent nature of the combining particles in all phases of the process. The psychologist has not as yet determined the principles which are required for a computation of the qualities which are associated with particular atoms, molecules, or other electrical combinations. However, we may say that in a general manner these non-human sentiencies are probably similar to those which are demonstrable in the human consciousness. By this we mean that they are generally similar to such things as colors, tones, temperatures, tastes, smells, and other so-called sensations or elements of consciousness. Or, if they are not of an elementary nature, they approximately resemble combinations of such elements — like human perceptions and other complex experiences.

Such a broad similarity of the nature of the sentient universe at large and the human consciousness in particular does not preclude important differences. Nearly all of the non-human sentiencies probably differ from any form of human consciousness as much as the most widely different of such forms differ from each other. Thus, red and sweet are two radically different qualities which are found in human experience; and we can readily conceive the possibility of some other quality which differs just as radically from both of them and which is not found in our experience. We must take the same attitude with regard to the non-human sentient universe that a color-blind man is forced to take concerning his normal fellow beings. He does not know and can never know the experience called red; yet he is constrained to believe in its reality. Similarly, the young child does not know the experience called *love* but may accept it as a fact in the lives of his elders.

Thus we describe the total sentient world as a system of qualities which fall into the same general class of things as do human sensations and feelings, but which nevertheless possesses a far greater variety than do the latter. The general pattern or structure of this sentient world is revealed by the physicist's mathematical description of the corresponding physical system. However, in passing from the physicist's account to a description of the sentient universe we must go through a process which is like translating from one language into another. We have endeavored to indicate the general nature of this translation, but the detailed rules are still part of "the mystery of mind" which the psychologist has yet to solve.

The Unreality of the Physical Universe

The above discussion has been an attempt to suggest the nature of the panpsychic world and its relationship to the world of physics. We have supposed that these two worlds exist, so to speak, side by side. Their structures and activities are "in parallel." To believe in the existence of a general sentient universe requires considerable intellectual courage. This is true even when we recognize that such a belief involves the same principles as does a belief in the existence of consciousness "in" our fellow-humans. It is true even when we see that this belief is more logical than the faiths of many popular religions. However, numerous philosophers have taken a further and far more daring step. They have denied the reality of the world of physics and have asserted that the panpsychic universe is the sole reality. This view of things has also been formally adopted by one popular religious cult, namely, that of Christian Science.

The proposition that the physical world does not exist seems at first to the layman as merely absurd. This is due, however, to his failure to understand the meaning of the statement. The proposition does not signify that the world of any man's senses is non-existent. This world is self-evidently "there." But where is "there"? Equally self-evident is the fact that "there" is *in the individual's consciousness.* No philosopher has ever intentionally denied the existence of consciousness in the sense in which we have interpreted the term in the present book. The world as we see it, hear it, touch it, taste it and smell it must always be acknowledged as a fact. But the same cannot be said for the universe of protons and electrons and Einsteinian space-time which is described by modern physical science. No one has ever seen this universe, nor heard it, nor touched it, nor tasted it, nor smelled it, in experience. Very few have even understood it. Belief in its existence is as much a matter of faith as is belief in the reality of the sentient universe of panpsychism.

We can go still farther than this in our statements concerning the physicist's world. We can state truthfully that this world *cannot be conceived as real*, unless we give it a panpsychic interpretation. One way in which the reader can convince himself of the truth of this statement is as follows: Try to *imagine* the nature of the nature of the thing called *electricity* of which the physical universe is said to be composed. Furthermore, try to imagine the difference between positive and negative electricity. Do not do this in terms of how they behave or how large the particles of positive or negative electricity may be. Try to conceive their inherent natures. If you believe that you have succeeded in the task thus set, note carefully whether you have inserted any qualitative factors into the scheme. Have you pictured the positive electricity as red and the negative as blue? Have you made the proton "hard" and the electron "soft"? If so, you must rule out these psychological features and start afresh in the experiment.

The final outcome is, either that you fail or that you are mistaken in your views, because physical particles are defined in terms of their relationships and not in terms of their inherent characters. In other words, they are blank units in an architecture of logic. Physics tells us the structure of the universe in the abstract. We must turn to psychology to find the substance which enters into this structure. And this substance must be of the nature of consciousness or its components. There is nothing else which we know in itself. There is nothing else with which our thought can ever be directly acquainted. This is because consciousness embraces everything concerning which such acquaintance is possible. We can know the world beyond us only in so far as it resembles the world which is within us.

Idealism

These are the tenets of an *idealistic* philosophy. The world is mind and mind is the world. The "mystery of mind" spreads over the whole of reality. And so the human mind loses its erstwhile uniqueness and is no longer a mystery. But the idealistic philosophers of the past have not solved the mysteries of the mental universe. They have lacked the proper instruments and methods. Some of these essential aids are being provided by modern psychology. Others, strange as it may seem, are to be found only in modern physics. A combination of the two provides the only means by which we can hope to penetrate to the details of realities which are still far hidden from us.

However, for those who have the interest and patience to delve into philosophical studies, it may be said that idealistic considerations are capable even now of solving some of the more general mysteries of mind. If the physical universe does not really exist, there can be no real problem of the relation of consciousness to matter. The real problem is that of the relationship between consciousness and the physicist's *theory*. The solution of the problem lies in a reinterpretation of this theory, so that it is given a new meaning. This new meaning is nothing more nor less than the panpsychic universe itself. Physical descriptions actually refer to this universe and to none other. The seeming interdependency of mind and matter thus reduces to the parallelism which necessarily exists between two different accounts of the same thing. However, we cannot hope in the present book to make such a doctrine really clear. To do so would be too difficult and if successful would unduly dispel the "mystery of mind"; which it has been our purpose to set forth rather than to solve.

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